Management of Cyprus fisheries

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Management of Cyprus fisheries

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PREPARATION OF THIS DOCUMENT

A first version of this paper was presented to the Committee on Resources Management of the General Fisheries Council for the Mediterranean under the title "The effects of new management measures on the Cyprus Fisheries: A lesson for the Mediterranean?" (Demetropoulos and Garcia, 1984). This updated version contains a new assessment, confirms the general conclusions of the original paper, and provides extended discussion on the regulation of effort in Cyprus.

The authors' sincere thanks are due to the staff of the Fisheries Department in Cyprus for providing us with data and for undertaking some of the computations, and to Francis T. Christy, Jr., Senior Fisheries Planning Officer, FAO for contributing a brief section on economic aspects.

ABSTRACT

The history of the Cyprus trawl and inshore fisheries is described, and the potential of the resources as well as the level of exploitation under the old management regime are assessed. The spectacularly positive effects of the extension of the closed season to protect the recruits are described both from the biological and economic points of view. A discussion is offered on the problem of regulation of the age at first capture and mesh size in a situation of severe overfishing. It is suggested that such a priori minor management measures, when correctly applied, might have positive snowball effects and might offer an opportunity for replication in the Mediterranean. Finally the paper underlines the need for proper control of effort levels if regulations of age at first capture are to be successfully implemented.

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1. INTRODUCTION

Natural living resources are renewable and can therefore sustain fruitful exploitation for long periods and, hopefully, forever if properly managed; if, however, they are misused, natural production can be severely crippled. Fisheries management is a difficult art and the present state of most fisheries in the world testifies to this.

The demersal fisheries of the Mediterranean are considered fully exploited and often severely overexploited, especially in the developed countries of Europe (Oliver, 1983; FAO/GFCM, 1981, 1982, 1982a). The General Fisheries Council for the Mediterranean (GFCM) has been promoting better management techniques for these resources, with particular emphasis on two major aspects of management: the regulation of age at first capture, through the use of appropriate mesh sizes; and the limitation of fishing effort. Theoretical calculations based on limited and sometimes rather poor data, have indicated that some gains can be expected from the implementation of appropriate measures. However, progress is very slow, especially in heavily overfished areas due to various reasons including lack of understanding of the consequences of excessive fishery development, of definition of objectives by higher authorities, of commitment by regulating authorities, of clear perception of the potential gains of the management measures and, consequently, passive or active resistance of fishermen to measures.

In 1982, the Fisheries Department of Cyprus started to implement a new fishing regime, restraining maximum fishing power of the already limited number of trawlers and, more importantly, extending the closed season by one month to protect juveniles during the very critical period of their arrival on the fishing grounds (Demetropoulos, 1985). The results obtained so far - equilibrium has not yet been reached - are spectacular and largely confirm the validity of the concept.

The following describe the past evolution of the fisheries; a first evaluation of the potential of the Cyprus resources, and of the level of exploitation before the implementation of the new management regime is also given. The first biological and economic effects of these measures are then described and a discussion of the complementarity between the regulations on total effort and on age at first capture follows.

2. BRIEF HISTORICAL REVIEW OF THE FISHERY SECTOR

The resources of the Cyprus shelf are shared by an inshore fishery, which has recently grown rapidly as a result of development schemes of the Cyprus authorities, and a trawl fishery whose size has decreased since 1952 when the number of boats was limited by law to 10 licensed Cypriot trawlers (this number was increased to 12 in 1961). The number of trawlers actually operating varied from 10 to 12 until 1979, when it was reduced to 8. The inshore fishery provided about 40% of the catch in 1961 (Fodera, 1961). Its share of the national production has since steadily increased and reached 64% in 1969. After a drop to 55% between 1969 and the 1974 conflict, the inshore fishery again developed very rapidly (Fig. 1). The fundamental characteristics of both fisheries from 1967 are given in Tables 1 and 2, and Figures 2 and 3 show the evolution of these characteristics in relative value, taking 1967 as the base (it is thought that the data collected after this date are more reliable). Figure 2 shows that the trawl fishery has been much more stable than the inshore fishery. Effort has decreased slightly, especially in 1979-82 despite gradual increases in average horsepower. Fishing intensity (effort per square mile), however, significantly increased after 1974 in relation to the reduction of available grounds from 846 to 507 square miles. Catch and catch rates decreased slowly but steadily from 1974 until 1982.

Table 1

Data on trawl fisheries

	Fishing effort			Trawler catch (tons)[a/]	Catch rate (ton/day)	Trawl fishing intensity[b/] (day/mile^2)	Total catch in Cyprus waters (tons)[a/]	Total combined effort in trawler days (x 10^3)	Total fishing intensity (days/mile^2)
	No. of boats	Average hp	No. of fishing days						
1967	10	162	1 462	433	.296	1.73	966	3.26	3.84
1968	11	180	1 502	499	.332	1.77	1 284	3.87	4.57
1969	10	182	1 575	433	.281	1.85	1 234	4.39	5.18
1970	11	184	1 718	503	.293	2.02	1 304	4.45	5.25
1971	12	198	1 722	457	.265	2.02	1 216	4.59	5.43
1972	11	205	1 868	557	.298	2.21	1 283	4.30	5.08
1973	11	210	1 820	564	.309	2.14	1 407	4.55	5.37
1974	(10)	190	1 623	525	.323	1.92	1 160	(3.59)	4.23
1975	9	200	1 284	342	.266	2.52	781	2.94	5.79
1976	11	213	1 324	353	.267	2.61	901	3.37	6.65
1977	10	215	1 295	333	.257	1.74	930	3.62	7.13
1978	10	215	1 521	356	.234	3.00	992	4.24	8.36
1979	10	215	1 562	343	.220	3.10	1 016	4.62	9.10
1980	9	221	1 333	250	.187	2.63	1 012	5.41	10.67
1981	7	233	1 162	238	.205	2.29	1 048	5.11	10.06
1982	8	241	1 100	266	.242	2.17	1 119	4.62	9.05
1983	8	241	1 213	451	.372	2.39	1 672	4.49	8.84
1984	8	n.a	1 248	453	.361	2.46	1 749 c/	4.84 c/	9.54 c/

a/ Refers to long tons - 1.026 metric tons = 800 okes

b/ (846 sq.n miles^2 before 1974 and 507 afterwards)

c/ Preliminary data - probably underestimated

Table 2

Data on the inshore fishery

	Fishing effort				Inshore catch (tons) a/	Catch rates		Inshore fishing intensity (hp days/ miles^2) b/	Total catch Cyprus waters (tons) c/	Total combined effort in inshore 10^3 hp days	Total fishing intensity hp days/ miles^2
	No. of boats a/	Average hp	Fishing days (x 10^3)	Days x hp (x 10^3)		Tons per 10^3 hp x days	Tons per 10^3 days				
1967	315	5.9	41.6	245	533	2.17	12.8	0.29	966	445	0.52
1968	315	4.5	39.1	176	785	4.46	20.0	0.20	1 284	288	0.33
1969	342	8.6	58.1	500	791	1.58	13.6	0.59	1 234	781	0.92
1970	359	8.9	63.1	562	801	1.42	12.7	0.66	1 304	918	1.08
1971	367	8.4	55.4	465	759	1.63	13.7	0.55	1 216	746	0.88
1972	376	9.5	47.4	450	726	1.61	15.3	0.54	1 283	797	0.94
1973	429	10.0	52.9	529	843	1.59	15.9	0.63	1 407	885	1.04
1974	460	10.9	41.0	(446)	635	1.42	15.5	(0.52)	1 160	816	0.97
1975	256	12.8	37.0	473	439	0.93	11.9	0.94	781	840	1.65
1976	322	15.2	43.6	662	548	0.83	12.6	1.30	901	1 085	2.14
1977	364	17.3	52.1	902	597	0.66	11.5	1.78	930	1 409	2.78
1978	385	18.2	55.2	1 000	636	0.64	11.5	1.97	992	1 550	3.05
1979	406	18.6	51.6	959	673	0.70	13.0	1.89	1 016	1 451	2.85
1980	447	19.0	51.2	973	762	0.78	14.9	1.92	1 012	1 297	2.53
1981	416	19.7	54.3	1 070	810	0.76	14.9	2.10	1 048	1 378	2.72
1982	465	19.9	58.7	1 168	858	0.73	14.5	2.29	1 119	1 533	3.01
1983	476	19.2	62.9	1 208	1 221	1.01	19.4	2.37	1 672	1 655	3.26
1984	n.a	19.2	62.2	1 194	1 296 d/	1.08	19.6	2.35	1 749 d/	1 619	3.19

a/ Refers to long tons = 1.026 metric tons = 800 okes

b/ 846 sq.n miles before 1974 and 507 afterwards

c/ Fishing boats are classed into 3 categories:
- Full-time boats - assumed to be fully occupied with fishing and taken as the basis for calculation of catch rates.
- Part-time boats - assumed to be 75% operational (catch per boat/day = 75% of the full-time boats)
- Occasional boats - assumed to be 25% operational (catch per boat/day = 25% of the full-time boats)

Numbers in the column represent the unweighted total. Full-time, part-time and occasional type of fishing is accounted for in column 3

d/ Assumed similar to 1983

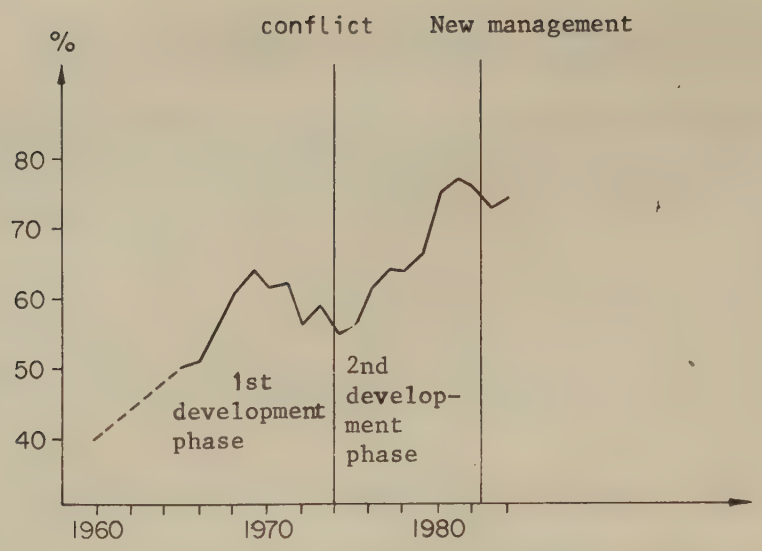

Figure 1 Inshore fishery contribution (in %) to fish production in Cyprus waters

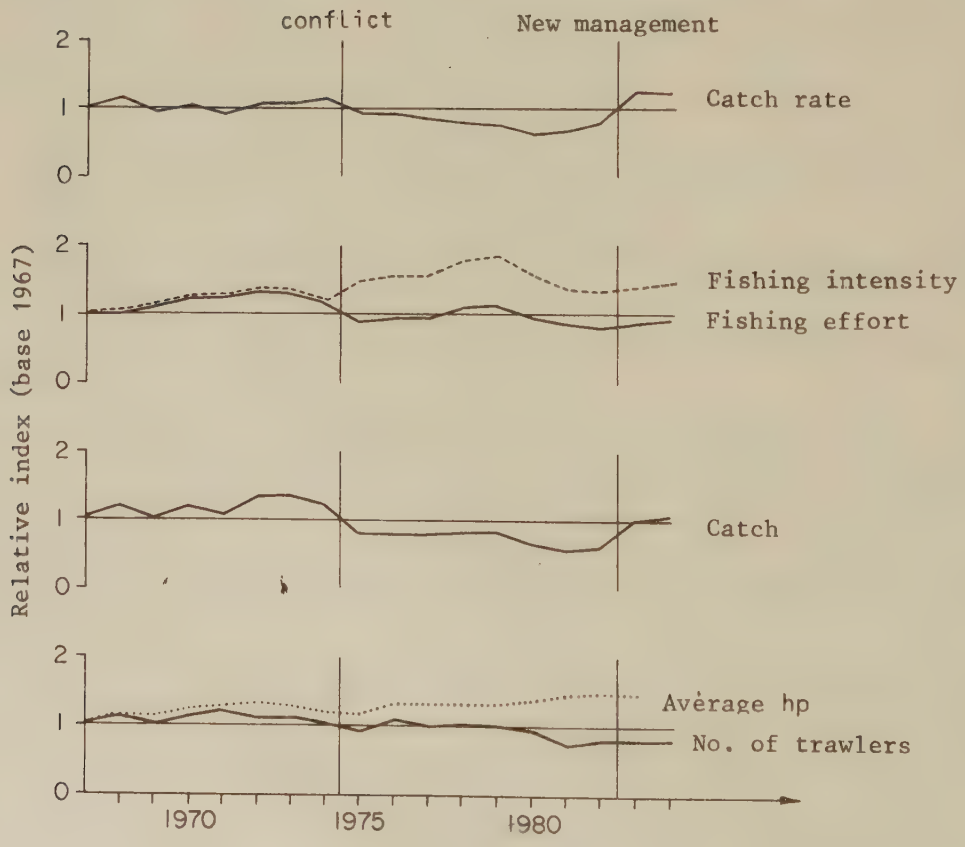

Figure 2 Relative variations of some characteristics of the Cypriot trawl fishery between 1967 and 1984
(The index is 1 for 1967 taken as the base year)

The inshore fishery showed a period of relative stability before 1974. Since this date, the fishing effort (in days) varied little; however, the effort per square mile increased (about 60%) as a result of the loss of fishing grounds after 1974. The catch per day remained fairly stable through the whole period, i.e., until 1983, but this result was obtained at the expense of a 3.5-fold increase in average horsepower. It is also known that, during the last years, this increase was paralleled by an increase in fishing power due to the use of longer nets and longlines as well as the introduction of hydraulic net and longline haulers.

Keeping in mind that the use of a direct proportionality factor between horsepower and fishing power might underestimate the true increase in fishing efficiency it was decided, for want of a better solution, to express the inshore fishing effort in (days x hp). An even better measure of fishing pressure was given by the fishing intensity expressed in (days x hp)/square mile, taking into consideration the changes in area fished before and after the 1974 events. Figure 3 shows that inshore fishing intensity increased about 8 times from 1967 to 1983.

The drastic reduction of the Cyprus fishing grounds resulting from the 1974 events amounted to about 40% in terms of area and a drop in production of about 630 tons. In 1973, production from the areas currently under Government control was about 670 tons. As a result of the need for reactivation of refugee fishermen and for production increases, fisheries development schemes led to increases in the inshore fleet and in heavy exploitation of resources in the areas that remained under Government control.

During the 1974-84 period, there was a highly significant upward trend in the real prices of fish received by the inshore fishery (Figure 4).[1/] The price of fish relative to the wholesale price for all commodities (i.e., the price deflated to remove the effects of inflation) rose by 45% between 1974 and 1982 (the last date for which the wholesale price index is available). Although there were moderate lows in 1975 and 1982, the overall trend indicates an increase at the rate of about 7% per year. This high rate of increase indicates that demand was rising more rapidly than supply; this is reflected in the large increase in fishing intensity relative to low increase in catch.[2/]

Another significant change occurred in the composition of the catches; a shift from high-value to low-value species. This is reflected in Figures 5-7, which compare the quantity of catch with an output index weighted by prices for each species in 1983. The simple addition of tons (or okes) of different species does not provide an accurate indication of the trend in the real output of the fishery since equal weight is given to species of high value (e.g., sea bream (fangri) at CL 6.5 per oke) and of low value (e.g., M. smaris at CL. 1.0 per oke). An increase in the unweighted quantity of catch does not show whether there has been an increase in the contribution of fisheries to the economy.

1/ A price index was constructed only for the inshore fishery since trawl caught fish are priced on four classes of fish graded not only by species but also by size and quality. The index was constructed on the basis of the Laspeyres formula $\frac{\Sigma p.q.}{\Sigma p.q.}$, using 1981-82 average catches as the base weights.

2/ This paragraph and the three following ones have been kindly prepared by F.T. Christy from the Planning and Policy Division of the FAO Fisheries Department

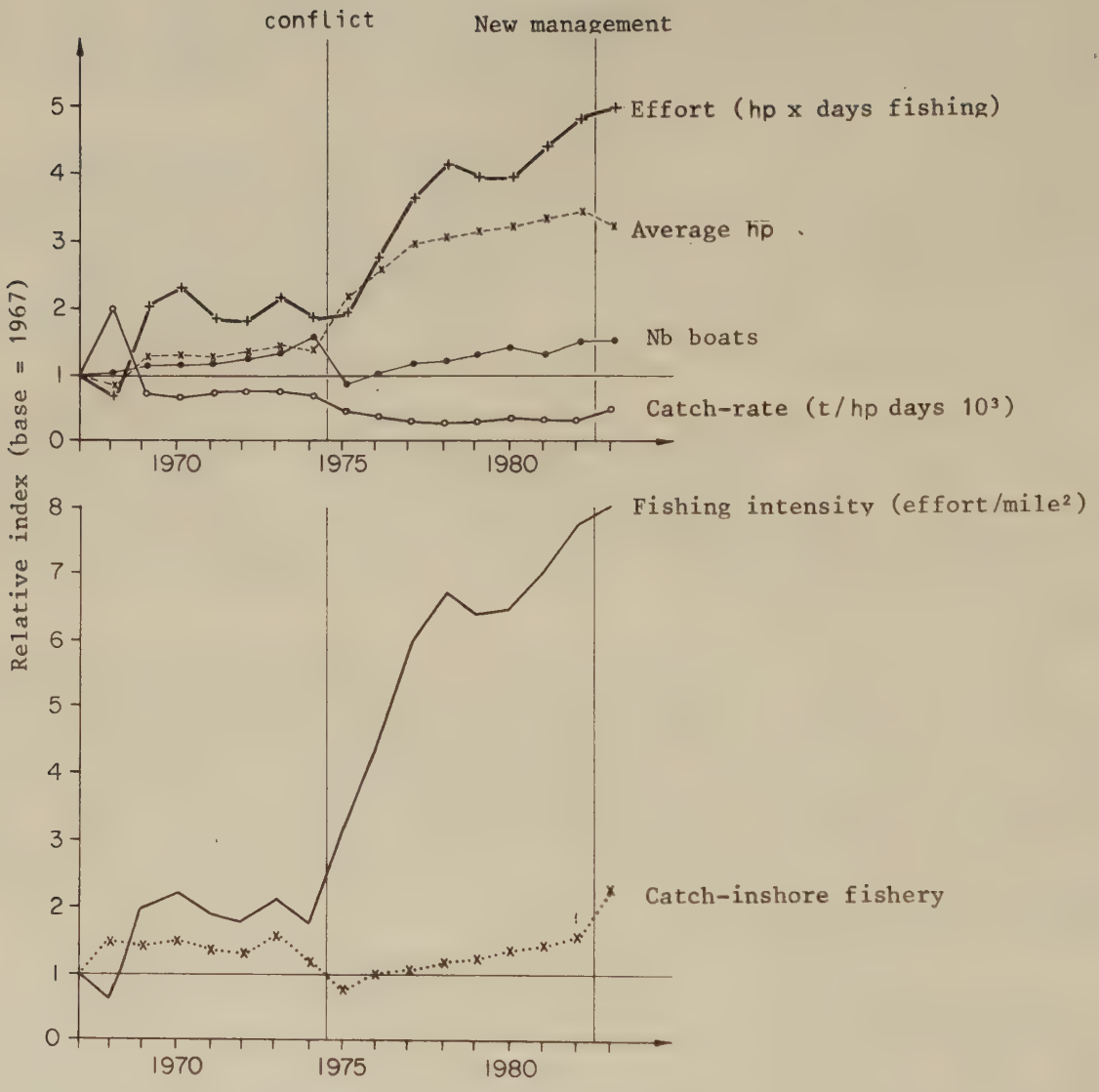

Figure 3 Relative variations of some characteristics of the Cypriot inshore fishery between 1967 and 1984
(The index is 1 for 1967 taken as a base year)

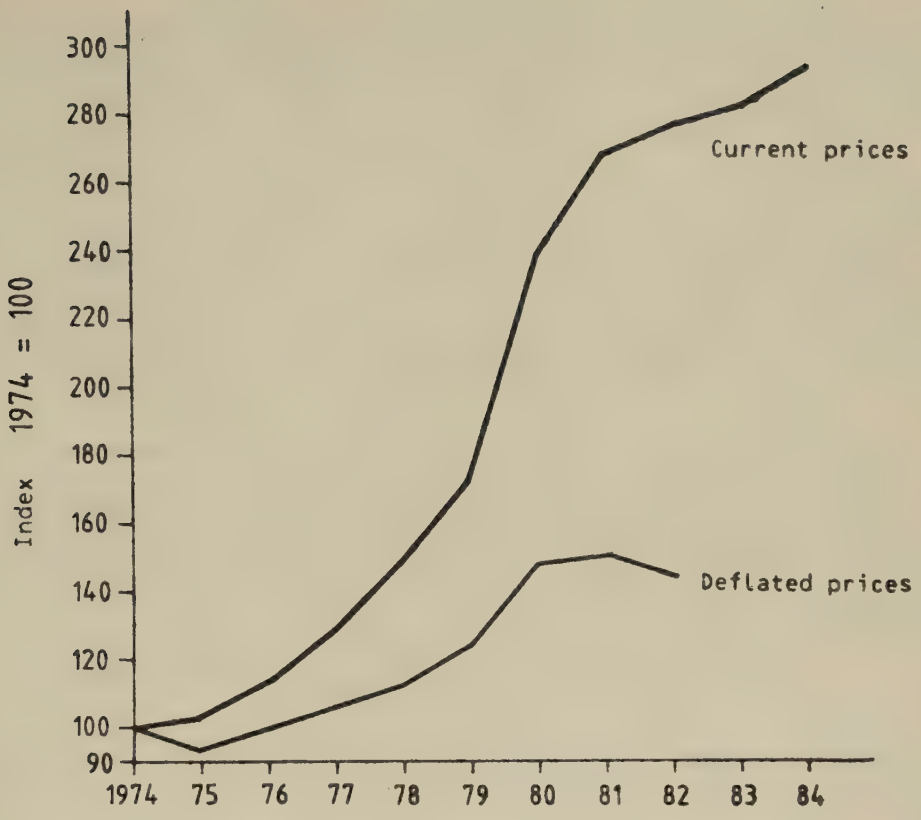

Figure 4 Changes in fish prices in the inshore fishery in current and constant prices

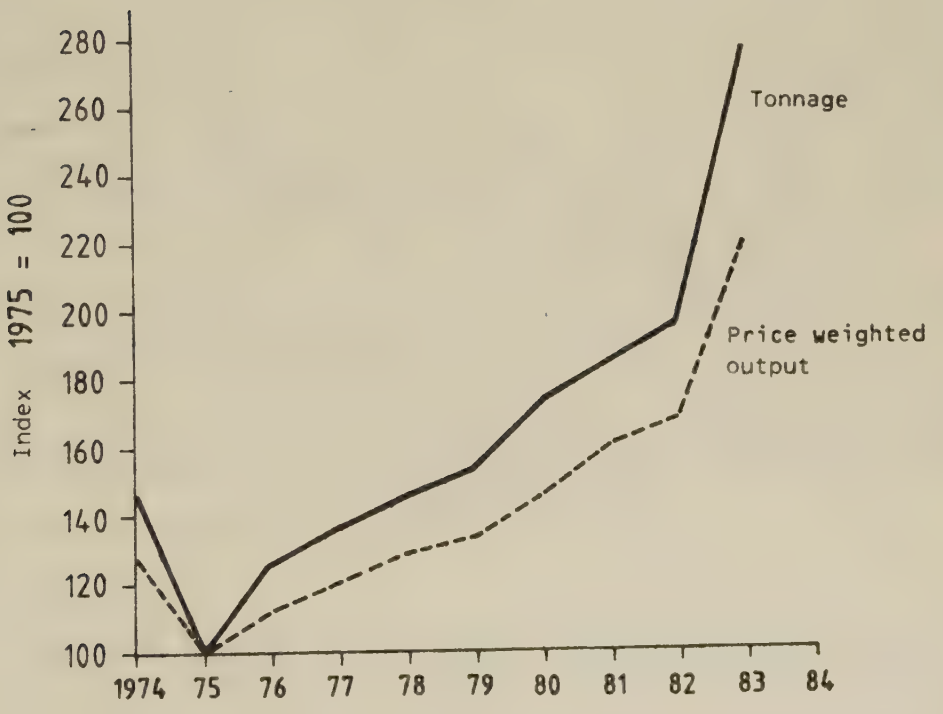

Figure 5 Inshore catch by tonnage and price weighted output

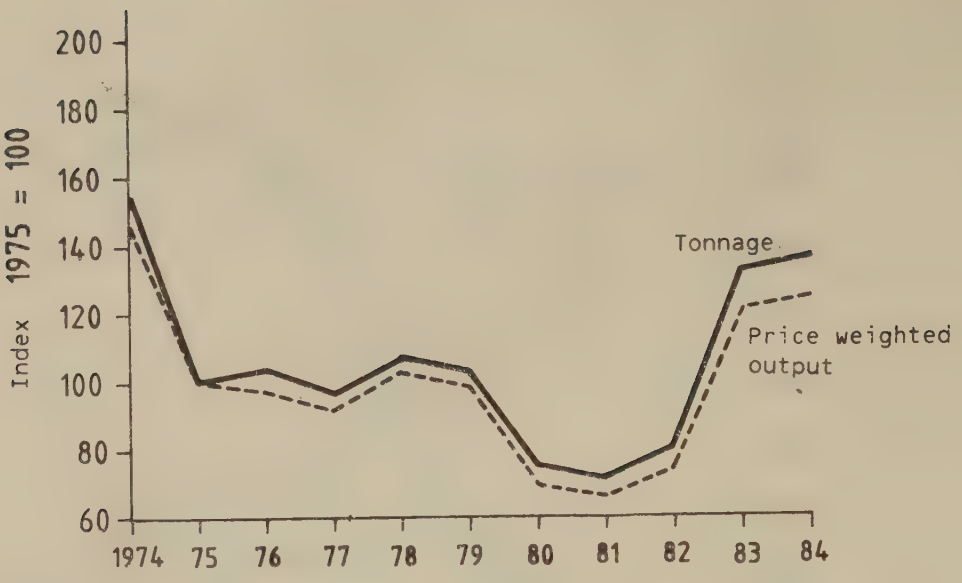

Figure 6 Trawler catch in Cyprus waters by tonnage and price weighted output

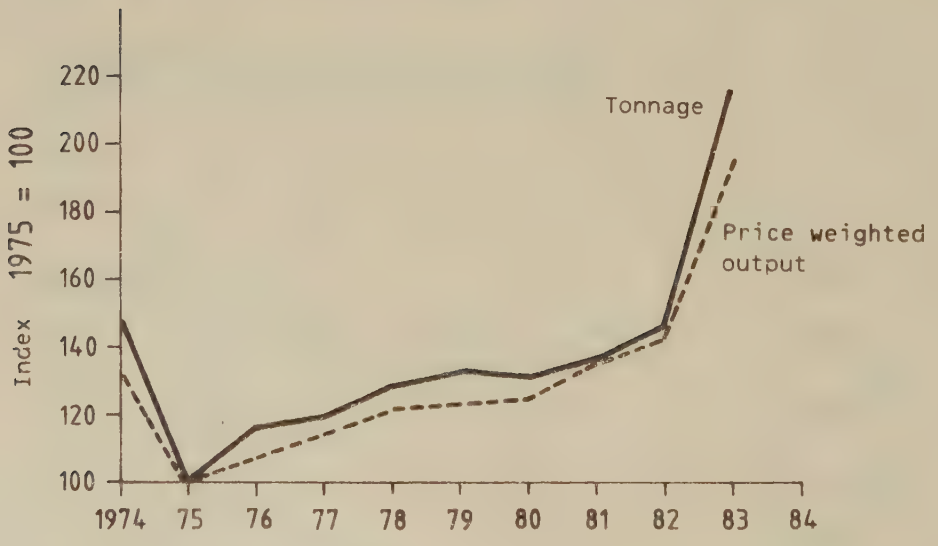

Figure 7 Total catch in Cyprus waters by tonnage and price weighted output
Index (1975 = 100)

A better indicator of the contribution of fisheries to the economy is achieved by adding up the catches of the different species on the basis of their relative importance in a particular period; in this case by using the prices in 1983. The output index thus derived is similar to those for agricultural products that combine the various products (e.g., oranges, wheat, lamb, etc.) on the basis of their prices.

The comparisons of the trends in unweighted quantities of catch with trends in price weighted output indexes (Figures 5-7) show that increasing proportions of the catches by both trawlers and inshore boats are made up of the lower value species. Between 1975 and 1983 in the inshore fishery, species valued at CL 4.5/oke and above declined from 35.5% of the total catch to 20.6%. Over the same period, species valued at CL 2.0/oke and below rose from 41.7% to 62.7%.

Trawlers were most affected by the decrease in the catch rates. Despite sharp rises in the price of fish (Table 3) they were apparently not able to compensate for it by opening new grounds or increasing fishing efficiency, as the inshore fishery did with the financial assistance of the State. The situation in the early 1980s was very difficult for them and fishing tended to be most intensive at the beginning of the fishing season when and where the new recruits were entering the fishing grounds. Trawler catches were therefore largely dominated by small-sized fish caught in shallow waters.

The fishery was mainly dependent on Maena smaris, which is a small fish mostly caught in its first year of life as a female (50-60% of the catch in 1975-80). Mullus barbatus, the other fish caught in quantity by the trawlers was very small, very often being too small to be of commercial size and was therefore discarded. In the landings, it averaged 11 cm in total length and was classed in the lower commercial categories (in category D or in category C if a little larger).

There were continuing and serious conflicts between the trawler owners and the inshore fishery as the trawlers' obvious heavy concentration on juvenile fish was believed to be the reason for the poor catches of the inshore fishery exploiting the areas near the main trawling grounds (in Limassol and Larnaca Bay in particular). In addition, the trawlers' constant trespassing in shallow waters (under the 30-fathom limit foreseen by law) where Maena smaris is mainly fished, interfered even more directly with the inshore fishery and with their fishing practices. Trammel nets, for instance, were frequently damaged by trawlers, specially in certain seasons when the inshore fishery had to fish in deeper waters.

By 1981 it was obvious that the trawler fleet was only marginally profitable on the basis of its catch in the territorial waters of Cyprus, and a subsidy scheme was put into effect to help these vessels fish in international waters during the closed season in Cyprus waters. This was quite successful and 5 vessels took part in it. Fishing in local waters was profitable mainly in October and November, during the recruitment period, while in the other months most boats were hardly breaking even.

3. MANAGEMENT IMPLEMENTATION

3.1 Old Fishing Regime

Before 1982, the following measures regulated fishing activity: the trawl fleet was not to exceed 12 boats even though the actual number varied between 10 and 11 and was reduced to 8 after 1979. The maximum horsepower per trawler was not specified and there was no limitation to the development of the inshore fishery. Trawling was forbidden in Cyprus from June to September inclusive (4 months), and in waters shallower than 30 fathoms (the latter was regularly violated).

Table 3

Producer wholesale prices for the trawl fishery
in Cyprus pounds per oke (1 oke = 1.28 kg)

Year	Commercial categories[a/]				Weighted mean value
	A	B	C	D	
1975	2.00	1.40	0.75	0.40	0.62
1976	2.00	1.40	0.85	0.45	0.63
1977	2.30	1.40	0.85	0.45	0.62
1978	2.90	1.60	1.00	0.50	0.72
1979	3.00	1.70	1.00	0.80	0.93
1980	5.00	3.10	1.80	1.00	1.31
1981	5.00	3.10	1.90	1.00	1.35
1982	5.50	3.50	2.00	1.05	1.40
1983	5.50	3.50	2.00	1.05[b/]	n.a.

1983 prices (November onward)

Squid and shrimp £ 2.25/oke
Groupers £ 2.50/oke
Octopus £ 1.40/oke

a/ These categories refer both to size grading and to different species mix

b/ From November 1983 any quantities over 40 okes (53 kg) over a two-day period were acceptable only at 75 mils/oke

In addition, the minimum mesh size was fixed at 32 mm (stretched). It is believed that the selectivity of the trawls was really very small or even nil as fishing in the heavy biological trash that is characteristic of most trawling grounds of Cyprus reduces the actual mesh opening to nothing by clogging. This is supported by Fig. 8, which shows no sign of decrease on the left-hand side of the catch curve of the apparent abundance of the younger fish in the catches of 1970, a year when sampling on board whose professional trawlers was particularly good.

The introduction of larger mesh size regulations, as recommended by GFCM, was not deemed practical at this stage as the trawlers were dependent on Maena smaris, whose adult size precludes the use of mesh sizes much above 34 mm. The frailty of Mullus barbatus had also been raised as an argument by the fishermen in opposing this measure as ineffective if the individuals released by the trawl did not survive.

3.2 New Fishing Regime

As is usual when fishing pressure increases and profitability goes down, the trawl fishermen were ready for some additional management measures provided the immediate cost to their already stumbling economy was acceptable.

In 1980, Trawler Owners' Association had suggested that the Government reduce the number of trawlers fishing in Cyprus to 5-6 by paying them compensation for giving up their "rights to fish in Cyprus waters." This "buying back" system had already been turned down as a choice by the Fishery Administration on "principle."

As usual in situations of overfishing, the trawl fishermen were also inclined to accept some restrictions on fishing time by lengthening the closed season (already extending from the beginning of June to the beginning of October), especially if it were extended to cover the month when fishing was least profitable, at the end of the fishing season (May in this particular case). However, if any positive effect was to be expected, the closed season had to be extended to October instead, when the main recruitment occurs and when fishing concentrates heavily in littoral areas, on juveniles (especially Mullus barbatus), catching small fish, a great proportion of which (below 8 cm) has to be discarded dead.

In the past, the inshore fishermen had made several requests for the curbing of trawling or its complete prohibition from Cyprus waters, and the move to close fishing in October had their wholehearted support. This support provided the political backing for the Government and the House to accept the measure, as about 700 families depended on this fishery compared to about 70 families in the trawler fishery, a large proportion of which were foreigners on contract as crew members.

Finally, the following measures were adopted:

(a) the extension of the closed period for trawling to include October. The new period is now June-October;

(b) the restriction of the horsepower of trawlers fishing in Cyprus waters to 250 hp for any new vessels entering the fishery to replace existing vessels. The total number of trawlers allowed to fish in Cypriot waters is restricted to 8 by discretionary powers of the Head of the Fishery Department.

This last measure freezes the total horsepower of the trawl fleet to 2 000 hp in the long run, which has been the average for the last 6 years.

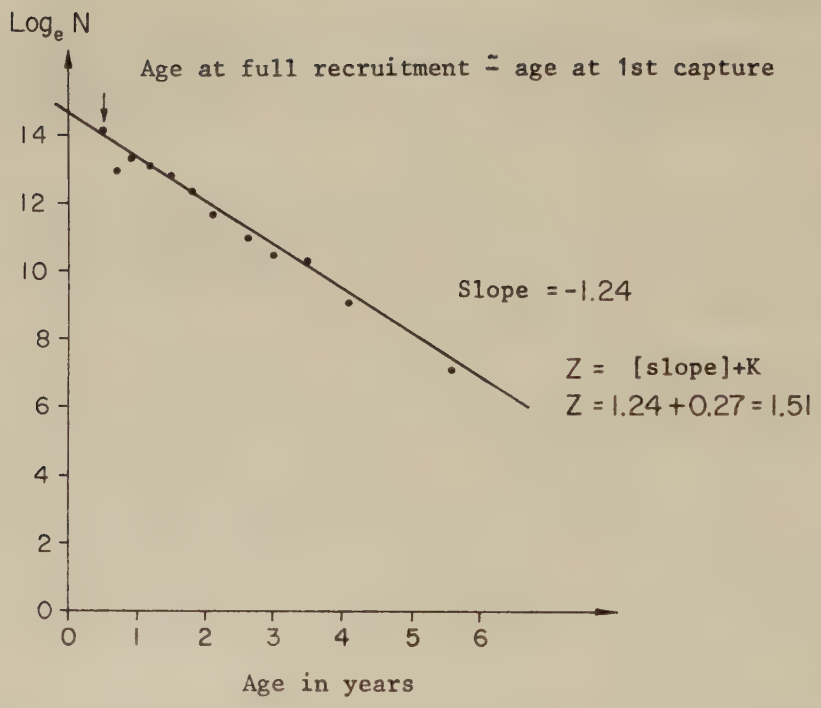

Figure 8 Length-converted catch curve for Mullus barbatus in 1970 (data from Livadas, pers. comm.)
(Data raised to total catch from 52 000 fish measured all year round on trawlers before sorting. Total mortality is calculated as recommended by Pauly (1983a))

In addition, a subsidy scheme was set up to help Cypriot trawlers fish in international waters during the 5 months of the closed season.

No enforcement problems were encountered as the prohibition to trawling in the closed season is absolute and, no trawler can leave harbour without the permission of the Fisheries Department Inspectorate. When outside harbour they have to keep to preset sea-lanes. The inshore fishery also acts as a control in this respect. It is clear that no illegal fishing by trawlers took place, or can take place, during the closed season and this was achieved at no additional expense for the Fisheries Inspectorate Service since it existed long before the new management measures were implemented.

4. RESOURCE POTENTIAL AND LEVEL OF EXPLOITATION UNDER THE OLD REGIME

4.1 Methodology

The only available estimate of the island's potential was made by extrapolation of the total production per square mile in Famagusta Bay (considered fully fished) to the whole island shelf (Demetropoulos, not published). On the basis of the 1970-73 average total production of 2.17 t/sq.mile, the total island shelf down to 200 m, with an area of 846 sq.miles, could be expected to produce about 1 850 t/year if biological productivity were similar all over the shelf.

The use of more sophisticated assessment methods is difficult because both the inshore and trawl fisheries exploit largely overlapping fish communities since many species range over the whole shelf during their life cycle, particularly a lot of valuable species, such as Mullus spp., Pagellus spp., Dentex sp., Maena smaris, Octopus vulgaris, Sepia officinalis, etc. This overlap implies a number of interactions and, although the inshore fishery also has access to species little exploited by trawlers (in rocky areas), it means considering the effect of both fisheries on the resource. This has been done by assuming that the global pressure exerted by both fleets can be measured by dividing the total catch by the catch rate of one of them (for want of a better method, with the available data.)

Another important difficulty arises from the fact that the fishery underwent considerable changes in 1974 and essentially suffered from an extensive loss of fishing grounds, rendering difficult the comparison of past and recent fisheries performance by the traditional production model. However, Caddy and Garcia (1983) and Garcia (1984) have advocated the use of Composite Production Models basically derived from the traditional model by using fishing effort per unit area instead of total effort on a fish stock as an index of fishing mortality. This method allows the use of data points from different areas with similar biological productivity but different effort levels to be grouped on the same graph, improving the fit by increasing the number of degrees of freedom and the range of variation of catch rates and effort.

This methodology has been used here in two ways:

Method 1. Two areas were considered: the whole island (before 1974) and the presently accessible grounds. The data expressed per unit of area allowed the use of the whole time series available from 1967 to 1982 on a single model despite the reduction of area available for fishing after 1974. This approach cannot, however, give a production model for the present fishing regime as only two points, 1983 and 1984, are available. The 1984 data for the inshore fleet used here are still provisional (and conservative) estimates.

Method 2. It appears that the presently available fishing grounds can be divided into 4 different areas (Figure 9), two of which are fished by trawlers and inshore fishermen and two nearly exclusively by the latter, because of their rocky nature. Each of these two sets of data contains a heavily fished area and a lightly fished area because of the presence or absence of big towns, easy access, and fishing vessel shelters. These circumstances have allowed us to elaborate Composite Production Models for two periods (before and after the extension of the closed season) and two "fishing regimes" (with and without (or nearly without) trawl fishing). It is believed that these two regimes differ by the average size of the fish at first entry in the fishery: it is much smaller in the trawl fishery than in the inshore fishery, which used trammel nets and longlines.

4.2 Assessment by Method 1

Two different assessments were made using the time series of catch rates available for the inshore as well as for the trawl fishery. The total catch in Cyprus waters was divided by the catch rate of one of the fisheries. The total effort obtained was then divided by the area available for fishing (846 sq.miles before 1974 and 507 afterwards) to obtain the fishing intensity. The relationship between fishing intensity and catch rate (Figures 10 and 12) provides for a standardized model (independent of ground size), which can then be turned into two models, one for the whole island and one for the presently available grounds by simply multiplying both catch and effort scales by the respective area (Figures 11 and 13). In the case of Figures 12 and 13, two different calculations were made. The first, using all the data points available (1974 was excluded because of the severe disturbances), using an exponential fit and the second, using only two stable (equilibrium?) periods, 1969-73 and 1977-82, and a linear fit. The results obtained were the following:

DATA SET	MSY (tons)		f_{MSY}		f_{1982}/f_{MSY}
	Whole island	Present grounds	Whole island	Present grounds	Present grounds
Using trawler's cpue data	1 770	1 070	9 000 days	5 500 days	0.93
Using inshore fishery cpue data (exponential fit)	1 740	1 050	$1\ 800.10^3$ hp days	$1\ 100.10^3$ hp days	1.23
Using inshore fishery cpue data (linear fit)	1 870	1 115	$1\ 700.10^3$ hp days	$1\ 050.10^3$ hp days	1.28
First rough estimate by Demetropoulos (unpublished)	1 850				

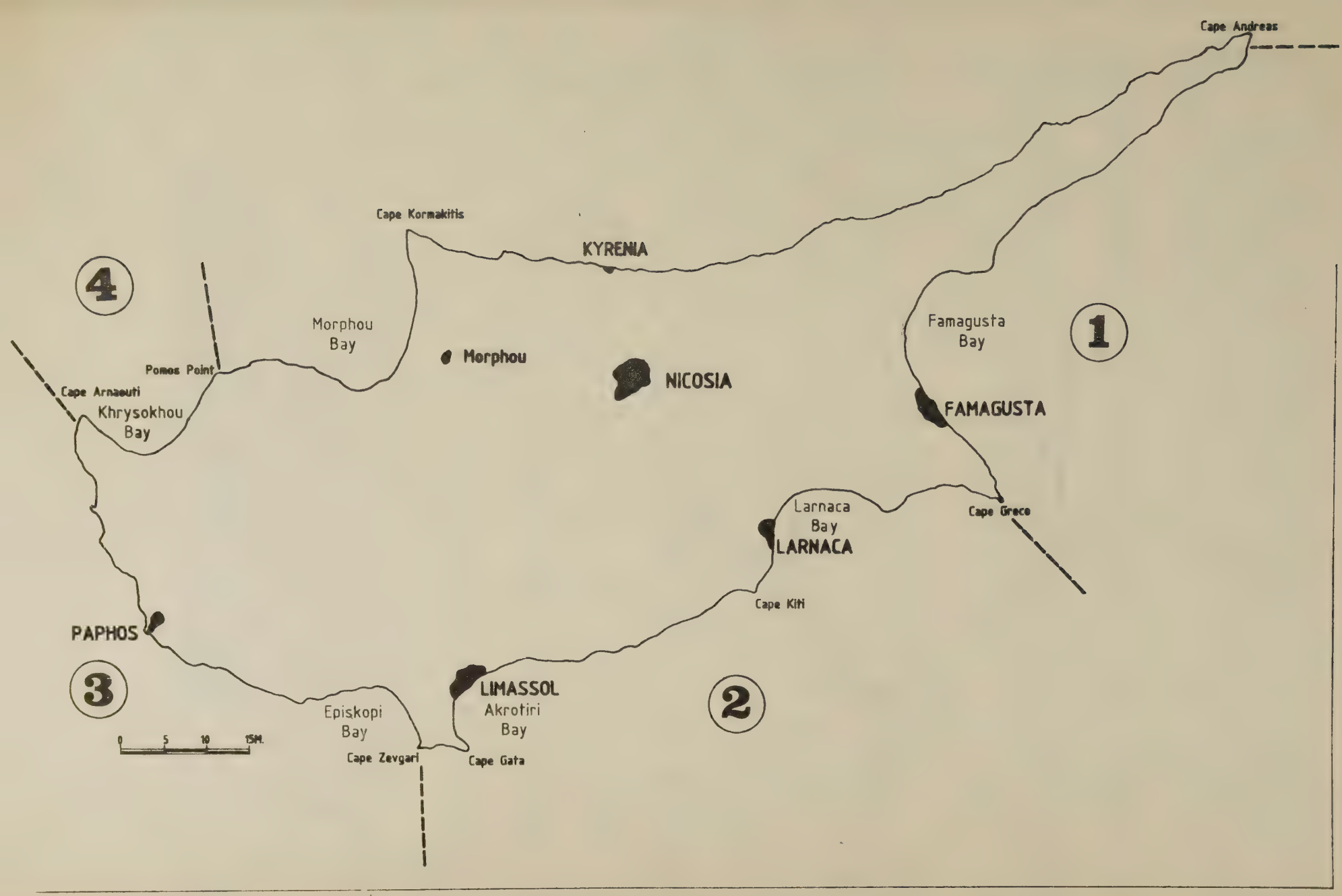

Figure 9 Map of Cyprus showing the 4 fishing zones considered in the analysis

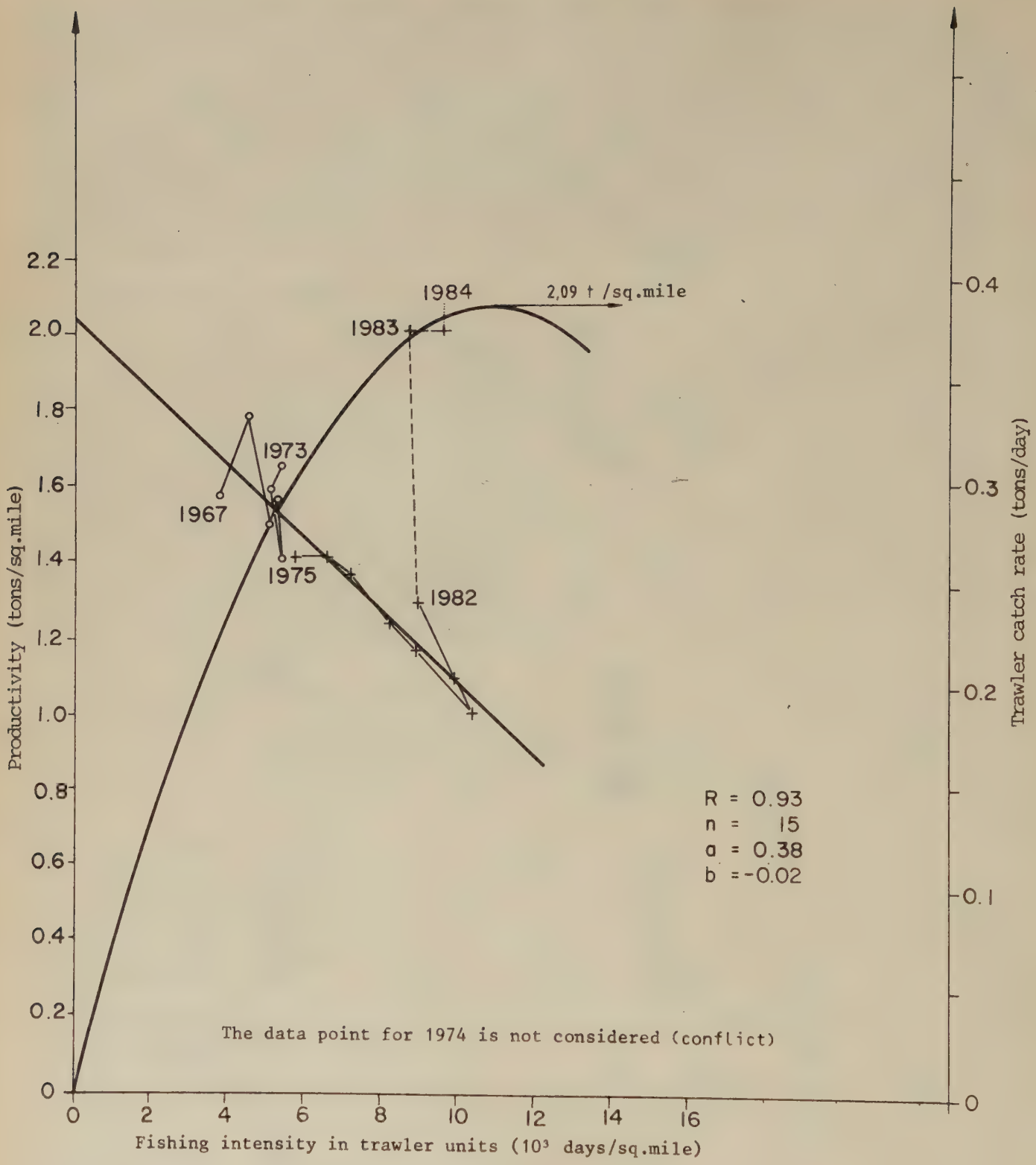

Figure 10 Relationship between fishing intensity (in trawlers units), catch rates and catch per unit area ("Productivity")
(The points for 1983 and 1984 not used for fitting show the change in productivity resulting from the new management measures)

The results are coherent. The agreement is very good on maximum sustainable yield (MSY) estimates. The values given by the models also agree very well with the first rough estimates made by Demetropoulos in 1975 (unpublished) by extrapolation from a small area (Famagusta Bay). The level of exploitation is indicated by the ratio between the present level of effort and the effort corresponding to the theoretical maximum catches: this ratio varies between 0.93 (close to "full fishing") and 1.23-1.28 (slight "overfishing").

Figures 11 and 13 show on the graphs the trajectory followed by the fishery and illustrate the pre-1974 and post-1974 situations. The fits are reasonably good and very good in the case of the trawl data (Figure 11).

On this evidence it is possible to conclude that, globally, the stocks of Cyprus in the areas now accessible were fully fished to slightly overfished when the new management measures were introduced, and that the potential of these grounds under the old fishing regime was between 1 050 and 1 115 tons/year.

4.3 Assessment by Method 2

Four areas as shown in the map in Figure 9 were considered. These areas were already in use by the Fishery Department for the compilation of statistics. For each area, the catch, effort and catch rate of the inshore and trawl fisheries were available (Tables 3, 4 and 5). Areas 1 and 4 received very little trawling effort because of the roughness of the bottom. Areas 2 and 3 contain the major trawling grounds (Bays of Larnaca, Limassol and Episkopi). The data on effort were then expressed by unit area. The total catch from these areas was divided by the catch rate of the inshore fishery (which exploits all areas and catches most of the fish) to give an estimate of total effort in inshore fishery equivalent units. To calculate fishing intensity, the result was divided by the surface area of the respective sector. Two periods were taken into consideration: 1977-1981 for the period before the introduction of the new management measures, and 1983-1984, which covers the period since the introduction of the measures.

The average values, with an estimate of their confidence intervals are given in Figure 14 and Table 5. This shows that:

a) areas with little or no trawling (areas 1 and 4) gave higher catch rates than areas heavily trawled (2 and 3) for equivalent levels of effort for both periods;

b) in both types of areas, the catch rates were substantially higher after the extension of the closed season.

This data set suggests that it is not satisfactory to pool all the catch and effort data from the 4 areas (though for the same time period) into a single production model. The heavily trawled areas have, therefore, been treated separately from the areas with little or no trawling (lines A1, A2, B1, B2). It is interesting to note that A1 and A2 as well as B1 and B2 respectively are nearly parallel. These lines have been used to calculate the productivity models (equilibrium production or catch per unit area, as a function of fishing intensity) given in Figure 15.

The effect of the new management measure is clearly seen. The potential has increased from 2.9 t/sq.mile to 5.8 t/sq.mile for the heavily trawled areas and from 3.8 t/sq.mile to 7.5 t/sq.mile for the lightly or non/trawled areas, therefore doubling the potential for all areas concerned.

Table 4

Catches for the inshore and offshore fishing by sectors, in long tons (see map in Appendix 1 for locations)

Area	Location	Fishery	Before extension of closed season						After extension	
			1977	1978	1979	1980	1981	1982	1983[a]	1984[b]
1	C. Andreas to C. Greco	inshore	37.7	46.7	41.1	59.0	62.2	79.0	92.2	94.0
		trawl	0	0	0	0	0	0	0	0
		total	37.7	46.7	41.1	59.0	62.2	79.0	92.2	94.0
2	C. Greco to C. Zevgari	inshore	413.9	429.3	470.2	548.0	574.9	611.4	939.1	1 069.3
		trawl	190.9	129.8	171.0	114.9	114.4	126.5	213.1	209
		total	604.8	619.1	641.2	662.3	689.3	737.9	1 152.2	1 278.3
3	C. Zevgari to C. Arnaouti	inshore	90.6	98.2	101.1	101.2	88.8	110.9	109.4/ (89.7)	134.7
		trawl	122.2	139.1	147.2	111.8	106.3	132.9	213.9	222.2
		total	212.8	237.3	248.3	213.0	195.1	243.8	323.3/ (303.6)	416.9
4	C. Arnaouti to Pomos	inshore	55.1	61.8	60.4	54.3	84.0	57.9	100.3	91.5
		trawl	11.9	27.3	25.2	23.3	17.6	7.0	13.0	22.5
		total	67.0	89.1	85.6	77.6	101.6	64.9	113.3	114.0

a/ For area 3 in 1983 official figures are in brackets. Values used have been corrected for under reporting (see text)

b/ Provisional data (underestimated) for inshore fishery

Table 5

Total catches (in 1. tons) catch rates (in 1. tons/10^3 days)
total calculated effort in inshore fleet fishing days (deducted from Table 5)
and total fishing intensity (in effort per square nautical mile)

Area[a/]	Data	Before extension of closed season						After extension		Averages	
		1977	1978	1979	1980	1981	1982	1983	1984	1977-81	1983-84
1	catch	37.7	46.7	41.1	59.9	62.2	79.0	91.7	94.0		
	catch rate	10.5	13.1	14.5	14.6	14.7	15.3	22.5	18.4	13.5 ± 1.6	20.4 ± 4.1
	effort	3.59	3.56	2.83	4.04	4.23	5.16	4.10	5.11	-	-
13 sq.m.	effort/n.mi^2	0.28	0.27	0.22	0.31	0.32	0.40	0.31	- 0.39	0.28 ± 0.03	0.35 ± 0.08
2	catch	604.8	619.1	641.2	662.8	689.3	737.9	1 152.7	1 278.3		
	catch rate	11.1	10.1	11.6	14.1	13.9	13.5	18.0	18.2	12.2 ± 1.6	18.1 ± 0.2
248 sq.m.	effort	54.48	61.28	55.30	47.00	49.60	54.70	60.00	70.2		
	effort/n.mi^2	0.22	0.25	0.22	0.19	0.20	0.22	0.26	0.28	0.22 ± 0.02	0.27 ± 0.02
3	catch	212.8	237.3	248.3	213.0	195.1	243.8	323.3 (303.6)	416.9		
	catch rate	13.2	14.4	20.1	20.0	17.2	19.1	24.4[b/] (20.0)	23.5	17.0 ± 2.8	23.9 ± 0.9[b/] (21.8 ± 3.5)
195 sq.m.	effort	16.10	16.48	12.35	10.65	11.34	12.76	13.2	17.4		
	effort/n.mi^2	0.08	0.08	0.06	0.05	0.06	0.06	0.07	0.09	0.07 ± 0.01	0.08 +0.02
4	catch	67.0	89.2	85.6	77.3	101.6	65.0	113.3	114.0	-	-
	catch rate	18.8	26.6	20.1	17.0	22.5	24.8	32.9	27.4	21.0 ± 3.3	29.9 ± 6.1
	effort	3.56	3.35	4.26	4.58	4.51	2.62	3.4	4.2	-	-
51 sq.m.	effort/n.mi^2	0.07	0.06	0.08	0.09	0.09	0.05	0.07	0.08	0.08 ± 0.01	0.075 ± 0.10

a/ Refer to Table 5 for geographical location

b/ Data between brackets are official figures. Data used have been corrected for significant under reporting in the artisanal fishery (see text)

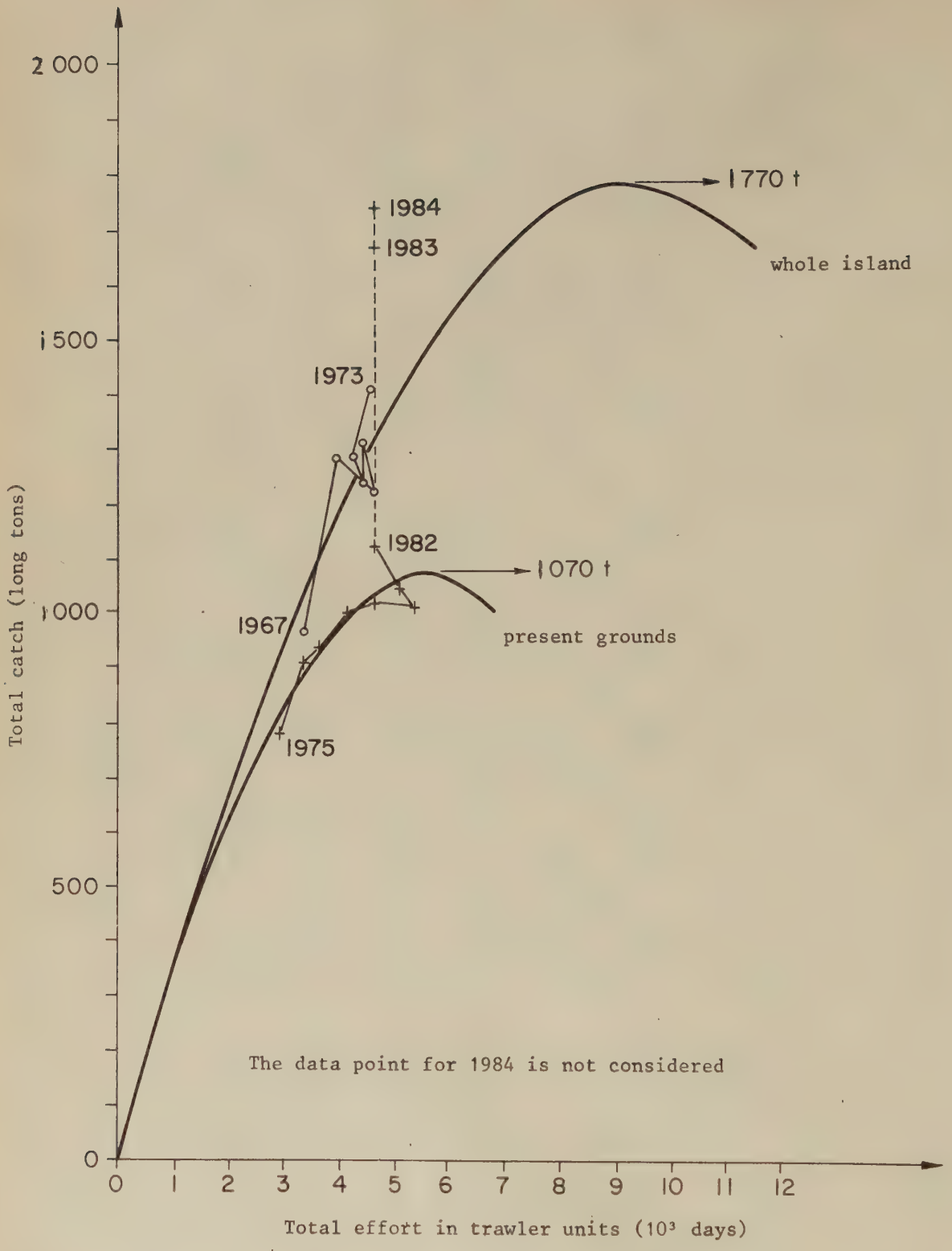

Figure 11 Production models for the whole island and the presently accessible grounds under the old fishing regime
(The points for 1983 and 1984, not used for fitting, show the drastic change in potential resulting from the new management measures)

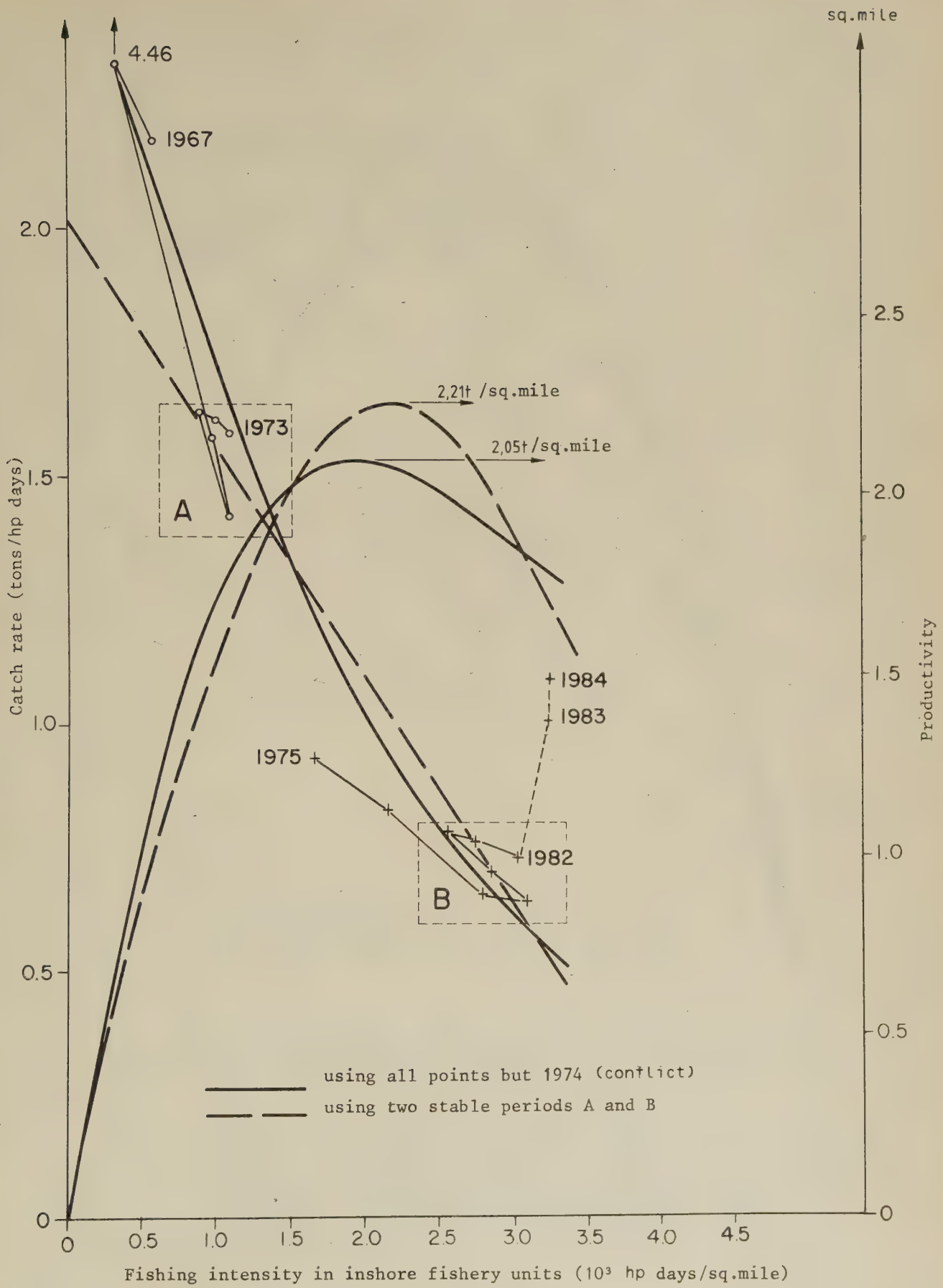

Figure 12 Relationship between fishing intensity expressed in inshore fishing units, catch rates and catch per unit area ("Productivity")
(The points for 1983 and 1984, not used for fitting, show the change in productivity resulting from the new management measures)

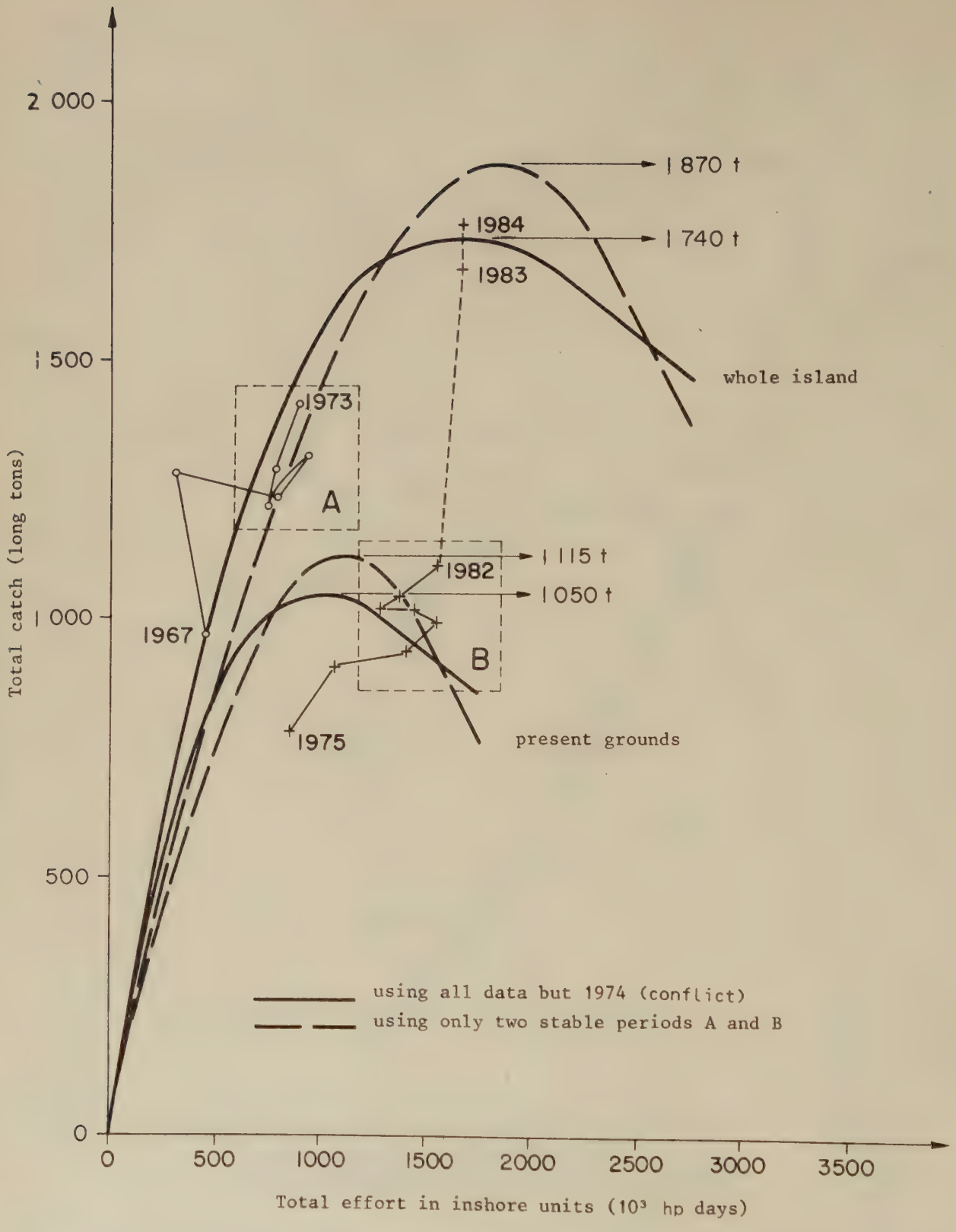

Figure 13 Production models for the whole island and the presently accessible grounds under the old fishing regime
(The points for 1983 and 1984, not used for fitting, show the drastic change in potential resulting from the new management measures)

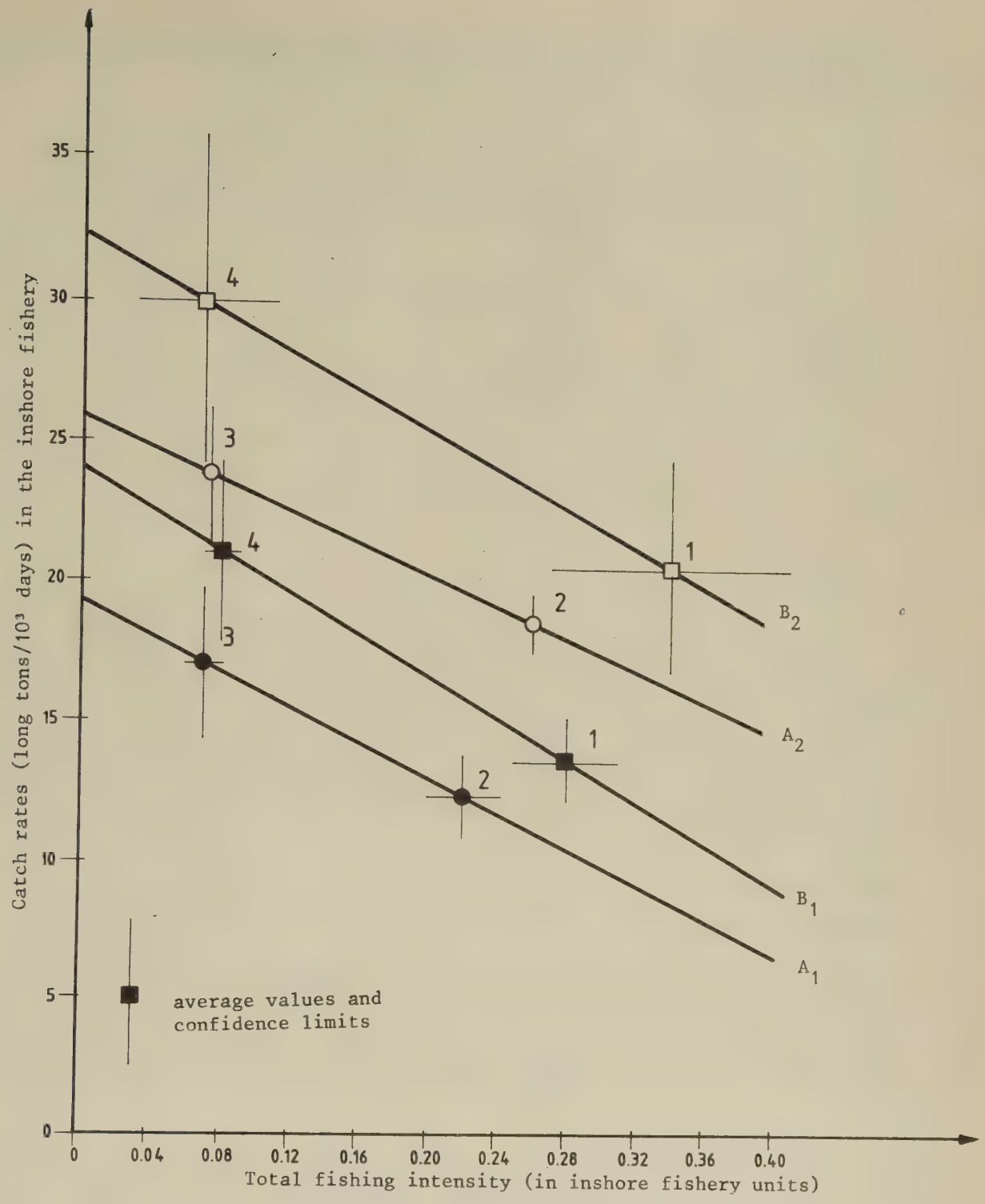

Figure 14 Relationship between catch rates and fishing intensity in areas heavily trawled and lightly trawled, before and after extension of the closed season to October
A1 and B1 = before extension, average 1977-81
A2 and B2 = after extension, average 1983-84

The potential and level of exploitation of the presently available grounds before the extension of the closed season could be estimated for each area as follows:

Area	Potential MSY/sq.m.	Fishing intensity f_{MSY}/ sq.m.	MSY a/	f_{MSY} (x 1000) b/	$\frac{f1977-81}{f_{MSY}}$
1 = 13 $n.m^2$	3.8	0.32	49	4.2	0.87
2 = 248 $n.m^2$	2.9	0.30	719	74.4	0.73
3 = 195 $n.m^2$	2.9	0.30	565	58.5	0.23
4 = 51 $n.m^2$	3.8	0.32	194	16.3	0.25
Total = 517 $n.m^2$	-	-	1 527	153.4	-

a/ In long tons
b/ In inshore fishing days

Method 2 therefore gives more optimistic results than Method 1 (1 050-1 115 tons). On the basis of Method 2, the potential of the present grounds appears to be on the average about 40% higher when the heterogeneity of the fishery is taken into consideration. The level of exploitation is more realistically depicted, and areas 1 and 2 appear to have been intensively fished (73 to 87% of f_{MSY} and possibly close to what is really economically feasible), while areas 3 and 4 seem to have been much less exploited (remote areas, specially for inshore fishing, less hospitable coast, scarcity of good shelters, etc.), and offer some scope for further development.

5. EFFECTS OF THE MANAGEMENT MEASURES

5.1 Effects on Landings

The average annual cycles of landings have been calculated for the pre- and post-conflict periods as a basis for comparison (Figure 16). The trawl fishing season used to start in October, with the highest catches (consisting of very small-sized fish) decreasing rapidly from November to May. The inshore fishery catches usually decreased in winter because of the weather. The important changes of 1974 did not affect these cycles in any way.

The average annual cycle for 1975-80 (after the conflict and before the new management measures) was used as a basis for comparison with recent landings (Figures 17 and 18 and Tables 1 and 2). In the trawl fishery catches, the increase was already significant by the end of 1982 and became very important by the end of 1983 when the new trawl fishing season started. The annual catches, which had been steadily decreasing at a rate of 17% per year since 1978, increased by 12% between 1981 and 1982 and jumped to a spectacular additional 70% increase between 1982 and 1983 leading to an 83% increase from 1981. No additional increase occurred in 1984 as the total catch seemed to stabilize at the new level. If the trawl fishing season (from October to May before 1982 and from November to May since then) is considered (Table 6 and Figure 19), the increase between the 1981-82 season and the 1982-83 season was 40%. This was the first season after the lengthening of the closed period. The results of the

Table 6

Monthly catches, efforts and catch rates of trawlers by fishing season

	Before the extension of the closure			After the extension of the closure					
	1981-82 Season			1982-83 Season			1983-84 Season		
	Catch (tons)	No. of w.days	Aver./W t/day	Catch (tons)	No. of w. days	Aver./W t/day	Catch (tons)	No. of w. days	Aver./W t/day
October	54.8	204	.269	0	0	-	0	0	-
November	42.0	172	.244	93.9	227	.414	138.0	195	.707
December	35.3	146	.242	47.8	171	.279	86.7	170	.510
January	37.5	180	.208	59.1	214	.276	88.6	207	.428
February	22.7	144	.158	47.8	185	.258	63.8	173	.368
March	27.0	140	.193	44.6	170	.262	52.3	153	.342
April	21.8	103	.212	47.1	199	.237	39.3	123	.319
May	22.3	135	.165	27.1	87	.311	45.5	177	.257
Total/mean/season	263.4	1 224	.215	367.4	1 253	.293	514.2	1 198	.429

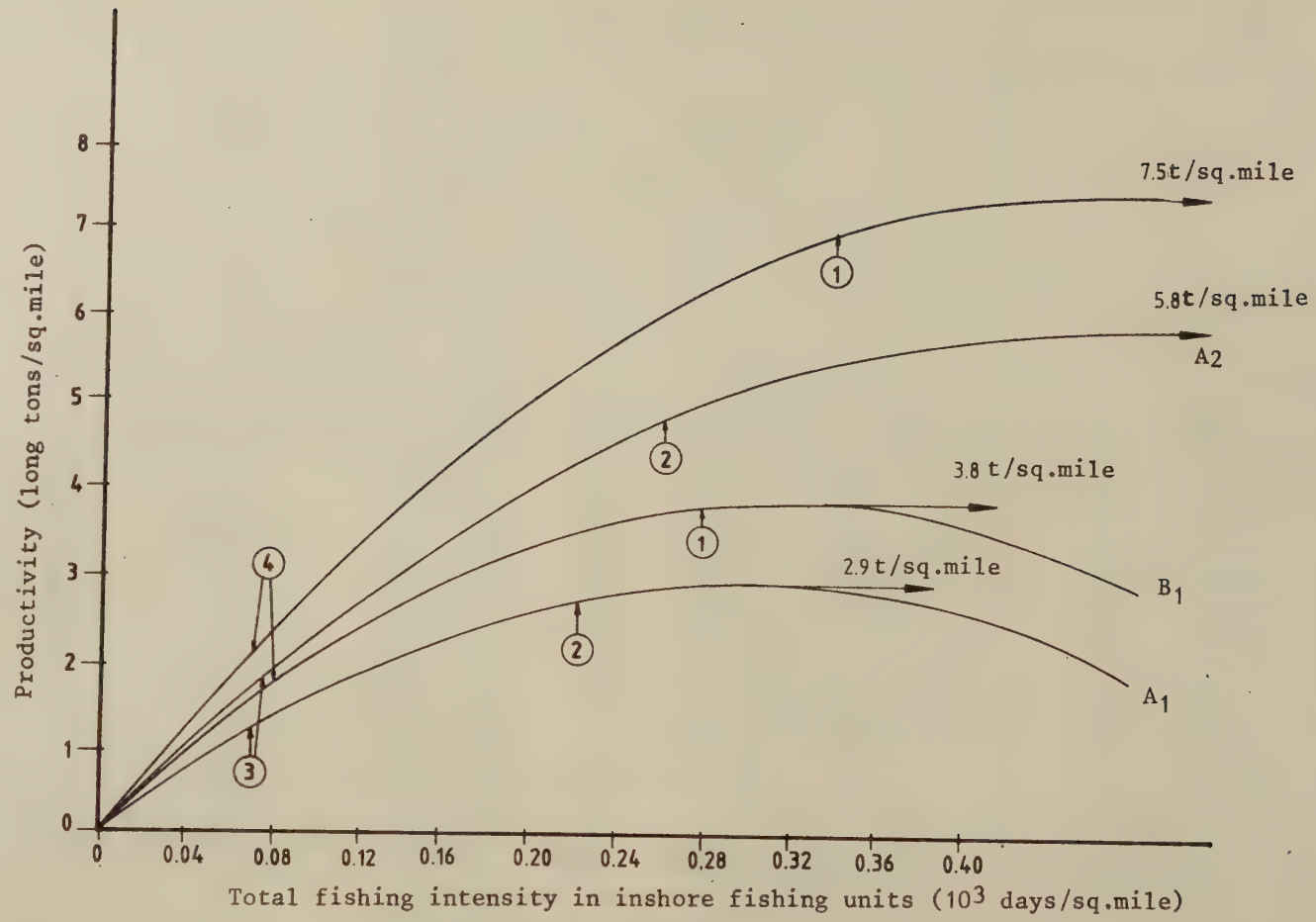

Figure 15 Evolution of the productivity (catch/n.m^2) with fishing intensity before extension of the closed season (A1 and B1) and after (A2 and B2) The curves refer to lines A1, B1, A2 and B2 in Figure 9

second season 1983-84 starting in November 1983 are even more spectacular. Production increased by 40% as compared to 1982-83 and by 105% as compared to the 1981-82 season. The very first data available for 1985 indicate that a slight decrease for the 1984-85 season is foreseen but the yields are still expected to be much higher than in the past.

The effects of the new management measures on the inshore fishery landings can only be indirect as the fishing activity itself has remained undisturbed by the new management regime. The effects are, however, at least as spectacular as those for the trawl fishery, largely confirming the interaction between these two activities, and justifying the joint assessment made in the preceding section. Figure 18 and Table 2 show the evolution of the monthly landings from 1981 to 1983 as compared to the average landings in the period 1975-80. The landings of the developing inshore fishery, which were increasing steadily at a rate of about 13.5% per year from 1975-82, increased suddenly by 42% between 1982 and 1983. The additional increase in 1984 [1] was about 3% indicating, as in the trawl fishery, that equilibrium may have been reached. These increases are equal to those experienced by the trawl fishery in its first season after the new regime, indicating that the immediate effects were of the same magnitude in the two fisheries. Catches of octopus were also very significantly higher in 1983 in the inshore fishery but returned to normal levels in 1984.

5.2 Effect on Catch Rates

The changes in the trawlers' catch rates (Figure 19) were even higher than those in catches as fishing effort in the 1983-84 season was voluntarily limited by the trawler owners who, after their initial doubts in 1982-83, were finally convinced that the increases in catches were really a result of the measures taken. At the beginning of the season fishing was reduced by one day a week and later by two or even three days as marketing problems forced the trawlers to curb fishing until their catches could be disposed of. Catches, effort and catch rates by month and by fishing season are given in Table 6. It can be seen that catch rates increased by 36% in 1982-83. The increase for 1983-84 is 99% as compared to 1981-82 and 46% as compared to 1982-83.[2]

In the case of the inshore fishery (Table 2), the catch/day has been about constant since 1980 (14.8 kg/day), increased sharply by 38% in 1983 and remained at about this level in 1984. The catch per hp. day decreased by 3% per year for the same period and suddenly increased by 38% between 1982 and 1983. No quantifiable information is yet available on the variations of average horsepower for 1984 but it has been assumed that no changes occurred since 1983.

5.3 Effect on Resource Potential

5.3.1 Changes in potential

The assessment of the potential maximum production given in Section 4 to serve as a basis for comparison with the new situation is only valid for the fishing regime implemented at that time. As a matter of fact, we can

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1/ 1984 data used here are preliminary information obtained just before printing and indicate in fact that the inshore landings reached 1 480 t (+22%)

2/ In fact the data used for 1984 are provisional and in reality the improvement is even higher (see footnote in para 5.1)

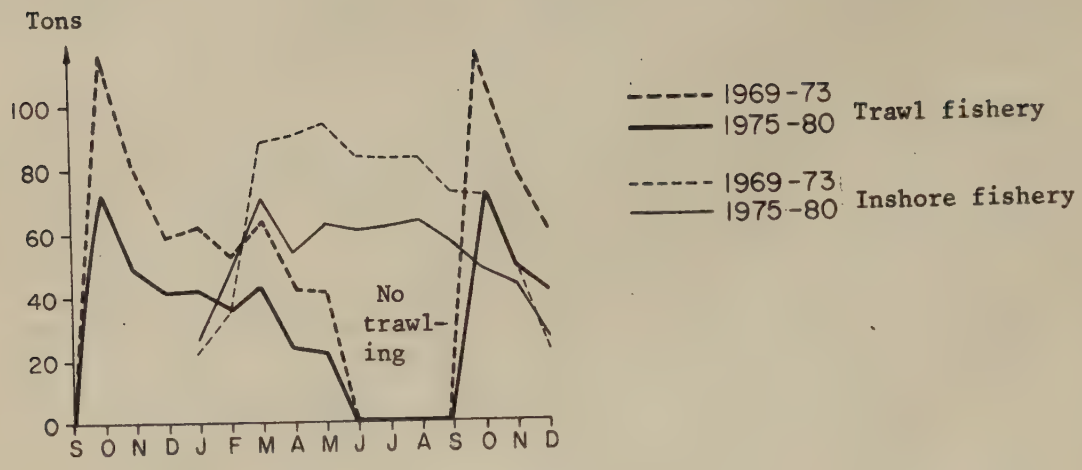

Figure 16 Seasonal patterns of landings under the old fishing regime before (1969-73) and after (1975-80) the conflict

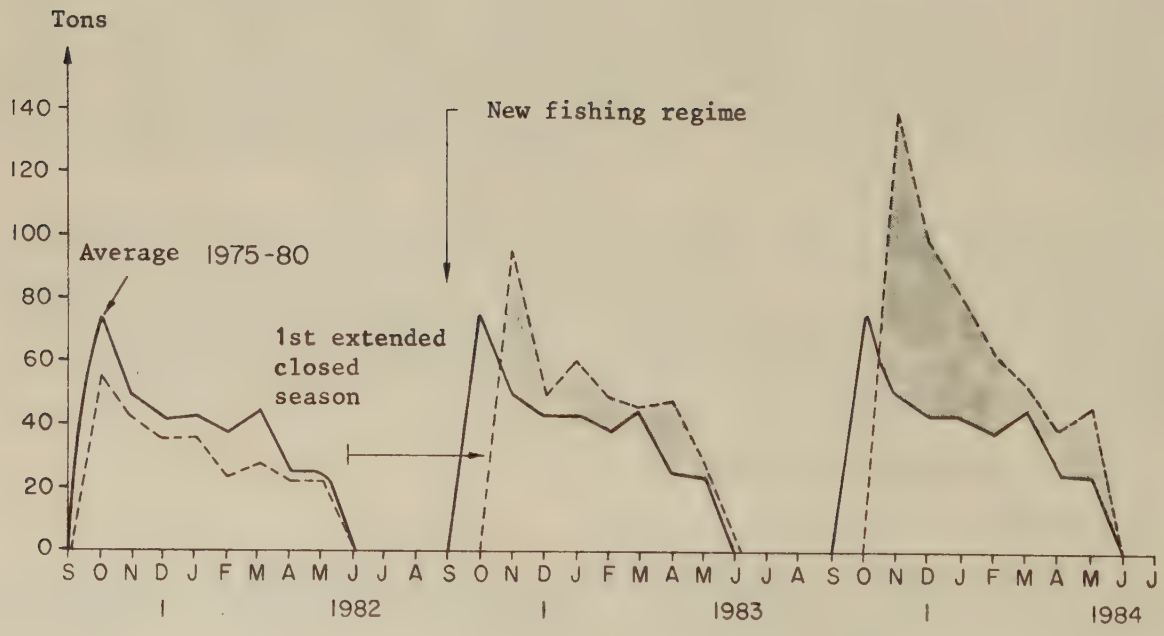

Figure 17 Seasonal landing patterns after introduction of the new fishing regime in the trawl fishery (the 1975-80 pattern is given for comparison)

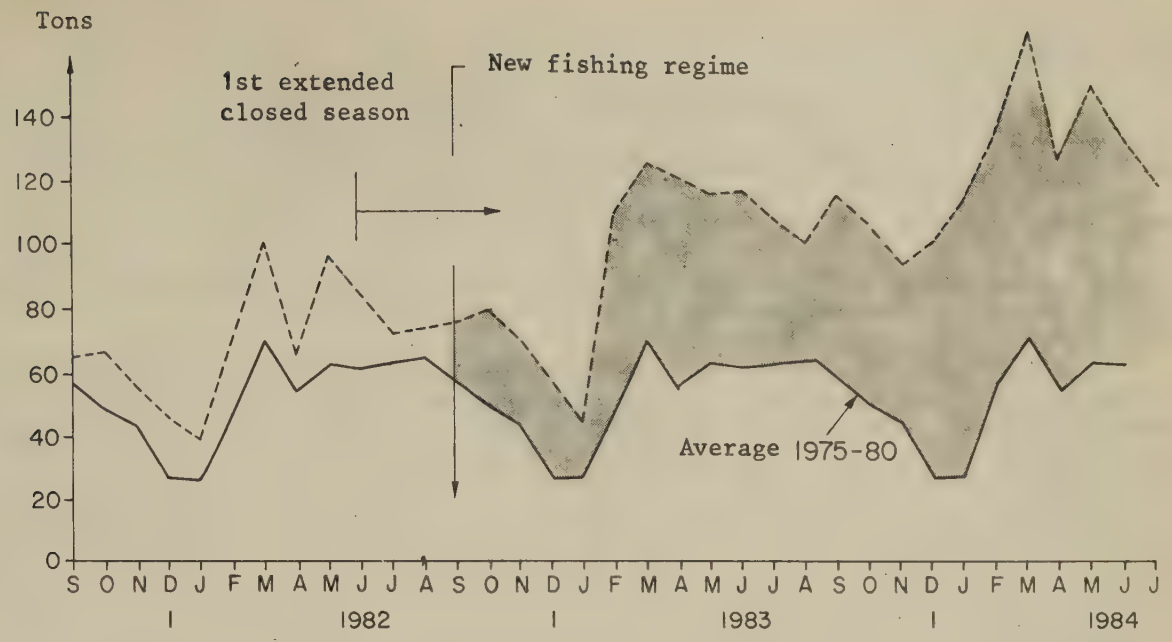

Figure 18 Seasonal landing patterns after introduction of the new fishing regime in the trawl fishery (the 1975-80 pattern is given for comparison), for the inshore fishery

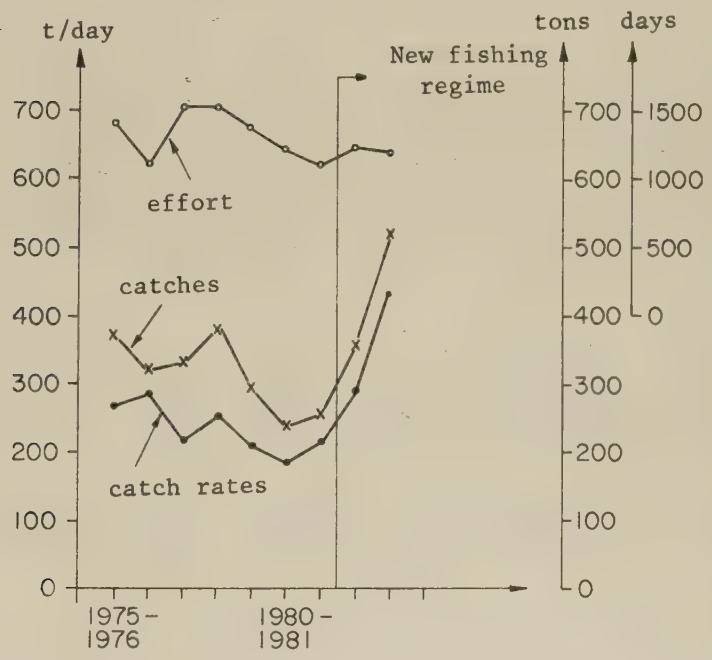

Figure 19 Trends in catches, effort and catch rates of trawlers, by fishing season and projections for 1983-84

state that

$$\text{Annual catches} = (Y/R)_{Fl,tc} \times R_F$$

where $(Y/R)_{Fl,tc}$ is the yield per recruit, which depends on the level of fishing mortality (F) and on the age at first capture (tc). R_F is the annual recruitment and it may be a function of fishing mortality (and stock size), especially when fishing becomes very intensive.

The new fishing regulation aiming at changing the age at first capture by delaying full fishing of immature fish by one month has certainly changed (Y/R)[1/]. The total combined effort (Tables 1 and 2) has apparently not changed greatly. In addition, the potential cumulative effect on recruitment of the increase in stock size (observed since the end of 1982) is not known. It is therefore clear that the production models established for the period before the new management measure was introduced have become obsolete and cannot be used for future predictions. Assessment Method 1 does not allow for the elaboration of a model for the new regime as the data points available are not sufficient. The position of these data points for 1983 and 1984 in Figures 10-13 are eloquent enough in this respect and indicate that the observed catches and catch rates for 1983 and 1984 are spectacularly higher than predicted by the "old" model. As expected, this shows, without any doubt, that the potential has been increased by changing the fishing regime, but it has increased by a factor that could hardly have been predicted with the available information.

Method 2, on the contrary, can lead to the elaboration of production models by area, corresponding to the new fishing regime despite the fact that only two years of data are available (1983 and 1984) and assuming that equilibrium has already been reached. In Figure 14, it can be seen that the two lines A2 and B2 corresponding to the new regime are positioned substantially higher than the ones corresponding to the old fishing regime (A1, B1). This shows that catch rates corresponding to a given amount of total effort are now much higher than before (by about +40% at low fishing intensity and +70-75% at high fishing intensity) in both lines.

Figure 15 also shows that productivity has increased by about 40% at low levels of fishing (areas 3 and 4) and 70% at high levels of fishing (areas 1 and 2). The maximum productivity has doubled, passing from 2.9 to 5.8 t/sq.mile in heavily trawled areas and from 3.8 to 7.5 t/sq.mile in the others.

The production models for the new regime, derived from Figure 15, are given in Figure 20 and the results are summarized in the following table:

1/ The yield per recruit (Y/R) that can be obtained from a fishery depends on the age at first capture, mesh size, closed season, or fishing pattern, other things being equal (growth, mortality, etc., considered unchanged)

Area	Potential per sq.m. a/ days)	fishing intensity f_{MSY}/sq.m	MSY a/	f_{MSY} (x 1000) b/	$\frac{f_{1983-84}}{f_{MSY}}$
1 = 13 n.m2	7.5	0.46	97	6.0	0.74
2 = 248 n.m2	5.8	0.45	1 438	111.6	0.58
3 = 195 n.m2	5.8	0.45	1 131	87.7	0.17
4 = 51 n.m2	7.5	0.46	382	23.5	0.15
Totals = 517 n.m2			3 048 t.	228.8	
Averages	6.7 +0.98	0.455 +0.012			

a/ In long tons
b/ In inshore fishing days

Comparing these estimates with the preceding ones (para. 4.2, Method 2), it appears that the extension of the closed season has doubled the production, which can be expected only if the appropriate level of effort is applied in all areas. It must, however, be noted that such an increase in fishing effort at the level of maximum biological production might not be economically or even biologically desirable. Some elaboration on this point is given in section 6.

5.3.2 Mechanism of the change

The unexpectedly high positive results of an a priori minor adjustment brought to a fishing regime, such as lengthening a closed season by 25% and delaying age at first capture by only one month of an intensively fished stock, raise some questions as to the main mechanism accounting for the increased productivity, as well as the possibility of replication to other overfished Mediterranean regions with similar communities.

A few preliminary calculations on the yield per recruit were made using reasonable values of total mortality (Z = 1.50, cf. Figure 8), natural mortality - (M) obtained from Pauly's equation (1983), and growth parameters taken from Tunisia (FAO/GFCM, 1982) and Cyprus (R.V. Livadas, in preparation) on Mullus barbatus, an important component of the catch and a good representative of a number of high-value, fast-growing species of the shelf community. The analysis, using yield tables, showed that assuming F and M were constant for the whole lifespan, the extension of the closed season by one month would rarely produce improvements above 10%, at equilibrium, by changing the present age at first capture from about 6 months to 7 or 8. However, some simple preliminary simulations with a drastically higher fishing mortality on age group 0 yielded much higher positive results when this mortality was significantly reduced.

Fishing mortality of very young fish was reflected by the dominance of group 0 in the catch, the importance of discards, and the concentration of fishing during the first months of recruitment (October/November, cf. Figure 21), especially in the shallow areas, infringing very often on the prohibited littoral area. The hypothesis that this mortality was very

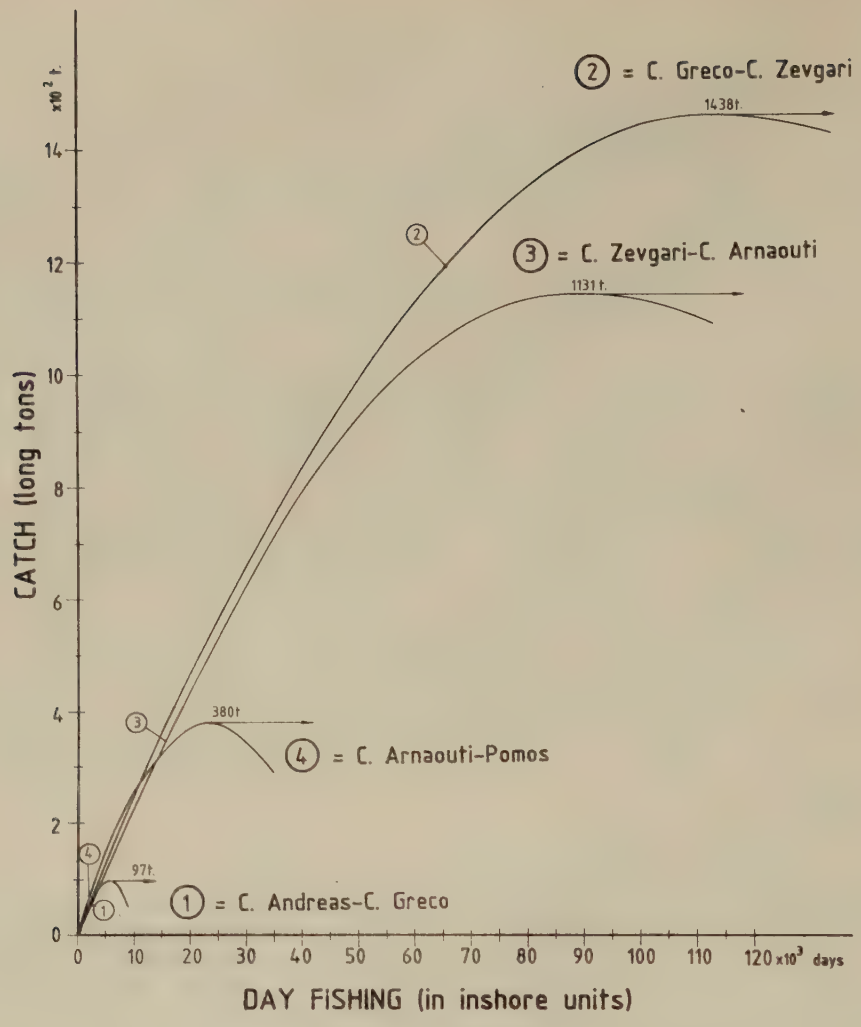

Figure 20 Production models for the various fishing areas as derived from Figure 10. The present position of the fishery on each curve is given by a number referring to the areas given in the map

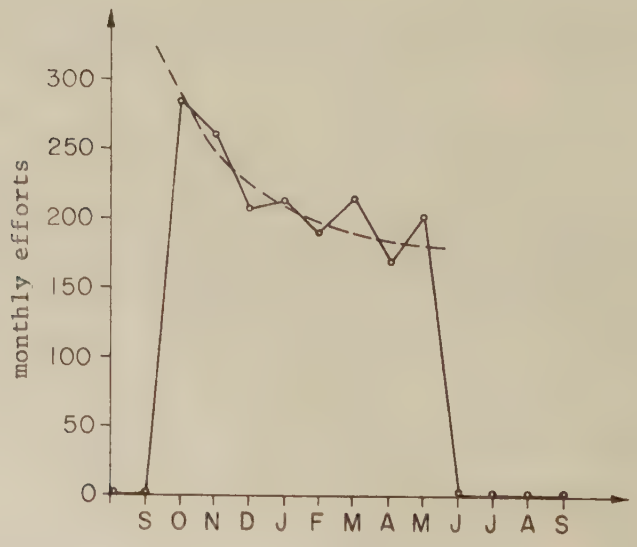

Figure 21 Seasonal pattern of fishing effort (average 1969-73)

hypothesis that this mortality was very high during the last years must therefore be seriously considered and gives a lot of credibility to the complaints of the inshore fishermen (who after all work also as crew on trawlers) that massive killing was occurring and that huge numbers of fingerlings were being discarded.

It must also be added that this is not new in the northern Mediterranean as this exploitation pattern (concentration on young cohorts as they come in and fishing them to near extinction in one year) seems to be a characteristic of many areas.

It is highly probable that, during the first year, the production increases resulted mainly from the protection in October of small fish like Mullus barbatus, which used to be heavily fished and thrown away as being too small to market. In November, these entered the lower commercial category (D) in large quantities, while larger individuals entered category (C), again in large quantities, during the year.

The catch in November 1983, one year after the start of the new regime, was characterized not only by a very significant increase in the quantity of Mullus barbatus in category (D) but also in very significant increases in the catch of this fish in higher quality groupings. This indicates that important long-term growth effects were already being perceived.

Finally, it should also be pointed out that sources of bias were examined for other causes that could account for the spectacular changes observed. It is clear that the catch of small fish discarded before 1982-83 had not been taken into account. It also appears that a small percentage of the catch (about 5%) is taken ashore by the crew and was not recorded before 1983. Some small underestimates of true catches in the "pre-management" period therefore occurred. It is also believed that some systematic under-reporting occurs even now. These sources of bias are however small and clearly not sufficient to throw doubts on the effects of the new management measures, effects confirmed on economic grounds.

5.4 Socio-Economic Effects

The income from increased catches at a lower input on the part of the trawlers has drastically increased profits, and fishing throughout the whole of the fishing season is now deemed to be very profitable, whereas it is clear that the trawlers were only breaking even during the last few months of the fishing seasons prior to 1982.

The increase in benefits in the industry is apparent in what is called "capital stuffing." Trawlers have acquired new electronic equipment and have for instance acquired another sophisticated sounder when they already had two. Some boat owners have undertaken costly overhauling, including modifications for more comfort at sea, without any loan. Pressures for increasing the present number of licences have increased. Inshore boats are also increasing rapidly and are acquiring impressive amounts of costly and efficient gears (modern net haulers, monofilament gillnets, etc.).

The new catch rates were such that they created new problems at the marketing level which, as mentioned previously, resulted in a voluntary curb on fishing by trawlers for a number of days per week in November 1983. Prices of fish from the trawlers remained nearly steady despite inflation, which is in the region of 5%/year in Cyprus. In fact, the retail price for Maena smaris dropped at certain times, i.e., at the beginning of the fishing season. Usually, ex-vessel prices for Maena smaris also drop by 25% for fish quantities in excess of a set daily maximum for each boat.

Marketing outlets - fishmonger shops, mobile units (vans) and street sellers - increased considerably since 1982, and new shops are appearing.

In expectation of high catches for the first few months of the 1983/84 season, all imports of fresh fish were banned, initially for the months of November and December 1983, but the ban was still in force at the end of the trawl fishing season.

The lengthening of the closed season for trawling could have created a problem of securing continued employment for the crews, skipper, etc., of the trawlers during the five months in which they would be unemployed at sea. In fact, there were no such problems for three reasons:

(a) because of the previously standing arrangement in which four months were closed to trawling, the crews were mainly foreigners who went to Cyprus on a contract basis. Skippers received salaries for the summer season, as did the first mate and, occasionally, the engineers;

(b) arrangements had already been made to encourage the trawlers to fish in international waters during the closed season, and an operational subsidy scheme was put into effect to bring this about;

(c) the greatly increased incomes for the trawler owners, many of whom work on the boats themselves, meant that problems could be dealt with easily. Even trawlers fishing only in Cyprus have had no problems since the 1982/83 season.

No new conflicts were created apart from those due to marketing the much larger quantities of fish which, in some cases, resulted in the refusal of the middlemen and fishmongers to accept certain species fished by the inshore fishery as they considered the market already saturated with the cheaper fish from the trawlers. New marketing outlets have, however, been set up and this has only been a temporary problem. The much higher catch rates of the inshore fishery also apparently had an effect on fishing for swordfish as fishermen preferred to fish profitably near the coast (and their homes) rather than go out several days at sea with a higher risk of not bringing in good catches of swordfish. Production of this fish dropped in 1983 to about 30 t compared to 120 t in 1982. The drop in production of swordfish may, however, also be attributable to other reasons such as unavailability of resources. At the time of writing this is being investigated. In fact, in 1984 and 1985 the higher prices of swordfish resulting from the lower catches led to greater fishing effort, and production increased substantially in these two years, reaching the 1982 level in 1984.

6. CONCLUSION

6.1 The Snowball Effects of Appropriate Closed Seasons: A Better Approach to Growth Overfishing Problems?

Growth overfishing occurs where there are losses of total catch because the fish is caught too early with a too high effort, therefore not being given enough time to grow. The state of the Cyprus fishery before 1982 had much in common with many Mediterranean fisheries: resources were heavily fished and the catch of the year depended largely on the new recruits to the fishing grounds in October. The recruits were heavily fished by trawlers in October and November and the survivors were the basis of a great part of the catch of the inshore fishery in the following year.

the inshore fishery in the following year. A number of immature fish were wasted and discarded, leading to a low yield per recruit and spawning potential. It can safely be said that the fish were being caught much too early. The Fisheries Department made a few unsuccessful attempts to deal with the problems through mesh size regulation but was faced with strong reactions from the fishermen, as is usual in the whole northern Mediterranean.

At this point, we must stress that we believe that the use of a small mesh size and/or the concentration of effort on small-sized fish during the recruitment period must be considered a consequence of "overfishing"[1/] and not its primary cause, even though it certainly greatly contributes to it. The main cause of overfishing is the excess of fishing effort expressed essentially in number of fishing units, total installed horsepower, or otherwise measured by the sum of all the means used to deplete the resource.

The problems created by the exploitation of a common property fish resource in the absence of limitation of fishing effort (and especially when subsidy schemes exist) have been discussed in detail by Pearse (1980) and FAO/GFCM (1982) in the case of the Mediterranean, and in FAO (1983) from a more general viewpoint. The regulation of effort, its limitation and the decisions on resources allocation that this regulation requires or implies are difficult exercises. Through lack of consciousness of the problem or fear of the difficulties involved, this regulation has not yet been properly implemented in most of the Mediterranean countries (nor in a great number of other areas in the world). Cyprus was probably one of the first Mediterranean nations to expressly limit the number of trawler licences as early as 1950. However, effort has continued to grow in the inshore fishery with governmental consent and backing.

The growth of the inshore fishery resulted in an effective increase in the overall fishing effort in the resources. This is due to the substantial overlap in the resources allocated de facto to the inshore and the trawl fisheries. This overlap was suspected on biological grounds and was in fact spectacularly proven by the impact on the production of both fisheries of a management measure theoretically affecting only the trawl fishery. The situation was further aggravated by the loss of fishing grounds after 1974.

In general, overfishing results in shortening the lifespan of fish, and in the reduction of the size of fish caught, their abundance, catch rates as well as in reduced profitability and frequently a shift in catch composition to lower valued species. Consequently, the trawl fishermen, who are always trying to optimize their operations, are forced to increase their pressure on younger fish in the short-term concentrating their activity on the periods when and the areas where the fish are most vulnerable. There is at the same time a trend towards reducing mesh sizes or the effective mechanical selectivity of the net.

Without addressing the primary cause of the problem (excess of overall fishing power), attempts to force fishermen to increase the mesh size (thus letting a great part of the catch escape) and to fish deeper (where abundance is much lower and profit are nil or negative) are not very successful. This has been demonstrated by the results of the last ten years of more or less dedicated efforts by many Mediterranean countries. The natural resistance of fishermen to regulation is abetted by favourable price changes in the market, which keep the fishing of small-sized fish still profitable.

1/ This term is used in a wide sense to indicate intensive, irrational and sub-optimal exploitation

In dealing with the problem of regulating age at first capture, it has already been stated that for short-lived animals (and an overfished Mullus barbatus is a very short-lived animal indeed!), closed nursery areas, closed seasons, and mesh size have similar theoretical effects by delaying the age at which the animal will first be massively caught (Hurley and Mohn, 1979; Garcia and Le Reste, 1981).

In the Mediterranean, the inshore areas (inside 3 miles, above 50 m or 30 fathoms) are theoretically prohibited to trawling, mainly to avoid conflicts between trawls and set gears. These can also serve as closed nurseries but the law is continuously broken in areas where trawling effort is very intensive. Under intensive trawling, the bathymetric position of the maximum financial return has moved progressively inshore as a result of population and market dynamics.

Closed seasons as a management measure are often, if not always, adopted since they can be enforced more easily. These seasons, however, are very often placed during periods when fishing is not profitable anyway, i.e., when the main annual cohorts have been driven down to unprofitable levels, and when fishing would have had to stop in any case. The decision is often justified by the fishermen's argument that the closure will protect the spawners (at least the remaining ones). This argument ignores the fact that there may not be any significant spawner-recruit relationship and, above all, that protecting immature fish would have a much greater positive effect on the abundance of spawners.

If closed seasons are to have an impact on age at first capture, they should be implemented during the main recruitment season. This is also, unfortunately, the period when in circumstances under which effort is excessive, the (residual) profitability of trawling is the highest. The Fisheries Department of Cyprus did this despite some resistance from the trawler owners, and was backed by the inshore fishermen who exploit the same fish many months later (sequential fishery), and therefore have an obvious interest in seeing less fish killed, at recruitment, on the trawling grounds.

The results, it must be admitted, go somewhat beyond what could have been objectively predicted, one of the reasons being that juvenile fishing mortality was probably many times higher than believed, during the first few weeks of benthic life when the fish are highly concentrated in limited coastal areas.

Snowball effects can be expected as a result of such measures. Biological effects (food-chain changes, recruitment enhancement, etc.) may occur but the most useful snowball effect may be on the fishermen's behaviour and on management itself. Here we may be extrapolating a bit beyond what is happening in Cyprus but the issue is worth discussing.

The trawl fishermen in Cyprus were very dubious in the beginning but are now convinced (and surprised) that the measure worked. Surprisingly, at the new fishing season in November 1983, they started fishing much further offshore and deeper than in the past. This was probably because the fish surviving from the preceding year recruitment were abundant enough to have apparently moved the depth of optimum economic returns seawards for the first time and because the new recruits had already migrated to deeper areas when fishing started. This shift has probably further reduced the mortality on juveniles. In 1984, the trawl fishermen formally agreed that they should now comply with the prohibition to fish in coastal areas at least during the first month of the season.

The fishermen, moreover, seem to be much less attracted by Maena smaris, a small, low-value, adult fish whose preponderance in the catch was their main argument in the past for not opening the mesh size. In

addition, there have been recent proposals by fishermen themselves to "open the mesh size in November and December when juveniles are still abundant." It seems that the fatal trends towards landing a progressively higher proportion of low value fish, as experienced in the past, can be stopped if the situation improves further. In the difficult world of management, such signs of self-generated positive management tendencies must be welcomed.

If we are not being overly optimistic, this behavioural change may demonstrate practically how, in the Mediterranean Sea in general, and in its northern part in particular, the problem of regulation of age at first capture could be most usefully addressed. It may demonstrate that in many overfished areas, where tackling the problem through mesh size regulation has met with apparently insuperable difficulties, a viable solution might be offered through appropriate closed seasons/closed areas, together with the initiation of an effective limitation of fishing effort.

One important problem remains in Cyprus: the resource potential has increased, but the intensity of fishing (i.e., in terms of hp/sq.mile) which year after year became locally very high and led to the 1981 situation, is still there, as is apparent from the effort measures and from the fact that the 0-group still seems to dominate in the catch. Effort has been cut back to 8 trawlers but the inshore fishery is still growing. Trawling time has been reduced voluntarily but trawl fishermen can increase fishing if the market demand expands (if export is intensified, for instance). Moreover, the abrupt increase in profitability brought about by management has generated an increased incentive for fishery development in both the trawl and inshore fishery sectors, as well as in the so-called "sport fishermen" sector (called "part-time" and "occasional" fishermen in Cyprus).

The number of trawlers is presently limited to 8 and horsepower to 250 hp, freezing the overall power to about 2 000 hp, but no limitation has been foreseen for the inshore fishery whose development in the past seven years has been spectacular. For the moment, loans for buying new inshore boats have been stopped and are given only for modernization of existing vessels.

The new management regime has broken a vicious circle of overfishing and low profitability and opened the door to more rational exploitation. However, it has at the same time created ideal economic conditions for a new vicious circle leading to more overfishing if total effort is not controlled. The new challenge for the near future is to set up a series of flexible, complementary measures (legal, economic and technological) so as to avoid the possible occurrence of a new "overfishing" situation. These measures are being carefully examined.

6.2 The Problem of the Regulation of Effort

If the results of Method 1 lead to the conclusion that the stock as a whole was slightly overfished in 1981, Method 2 allows for a more refined areal approach to management. Areas 1 and 2 (from Cape Andreas to Cape Zevgari) appear intensively fished (f 1983-84/fMSY = 0,58-0,74) while areas 3 and 4 appear underfished (f 1983-84/fMSY = 0,15-0,17). The problem of effort regulation should therefore be approached with the idea that the appropriate amount of effort is a matter of government policy. On purely biological grounds, there may not be a real need to reduce fishing pressure globally and there certainly is some scope for fishery development in the western and northwestern parts of the island. This is a particularly fortunate situation for the Fisheries Department as reducing effort would

certainly be a very difficult task. There is, however, a strong need to control any further growth of the inshore fleet and to attempt to distribute its fishing pressure more evenly all around the island.[1/]

Comparing these estimates of potential obtained by Method 2 before and after the extension of the closed season, it appears that the extension has doubled the production that could be expected if the maximum level of effort is applied in all areas. However, this would mean increasing the present level of effort by 35% in area 1, 73% in area 2 and 500% in areas 3 and 4. While it may seem justified to try to exploit areas 3 (in its northern part essentially) and 4 more intensively by building more fishing shelters and allowing more inshore boats into the fishery, it may not be biologically and economically desirable to increase fishing effort to the maximum or to increase it at all in areas 1 and 2. A more realistic view would be to consider the possibility of increasing the effort in areas 3 and 4 in order to bring their level of exploitation to that presently applied in areas 1 and 2 (about 66% of fMSY on the average). We know that fishing at this level is still profitable at present while the fishing pressure is already very high as evidenced by the small sizes in the landings and the conflicts experienced in the past between the inshore and trawl fishing fleets. It can be noted in this respect that the catch level of 0.66 MSY is also used in the temperate seas to define biologically safe and economically viable fishing objectives for management of multispecies resources.

In practical terms, limiting effort at 66% of fMSY everywhere would mean freezing total effort at the present level in areas 1 and 2 and allowing an increase of about 43 000 more days of inshore fishing in area 3 and about 12 000 days in area 4. The present total effort exerted in Cyprus expressed in inshore days of fishing equivalent is about 89 000 and the above suggests, therefore, that a 62% overall increase is still possible on purely biological grounds. These increases of effort in areas 3 and 4 to about 66% of fMSY would in theory generate an additional total catch of 1 345 tons (+77%), provided this additional effort is properly distributed. However, this would also reduce the economic profitability of the fishery and would probably not give the Cyprus Government the possibility of extracting a significant rent from the fishery. Because of the obvious limitations of the model, these conclusions should be regarded with some caution, and a progressive approach adopted in order to re-assess the state of the stocks by area as the fishery develops under tight control and to monitor closely the economic effects. In particular, the data and the assessment must be refined for area 3 (Cape Zevgari to Cape Arnaouti), which could usefully be subdivided in a southern area with heavy trawling (Episkopi Bay) and a northern area with nearly no trawling at all, the potential for expansion being limited most likely to the northern area. In addition, the composite model for the new fishing regime should be updated with the final 1984 estimates of landings.

The concept of management by area and optimum space distribution of effort in Cyprus is a new concept, which may meet with difficulties if tentatively implemented, but the potential benefits are such that it is worth considering for discussion with fishermen's associations.

1/ Economic studies based on the biological models presented in this paper are being undertaken and suggest that reduction of effort would probably generate some amount of economic rent (R. Hannesson, in preparation)

If this approach does not appear to be feasible and only the total effort for the whole island can be controlled, then the effort should be frozen at the present level until the fishing conditions in areas 3 and 4 have improved (better shelters), fishing effort is more evenly distributed and new assessments made under these conditions. The conclusions of the economic analysis undertaken by Hannesson should also be carefully considered.

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